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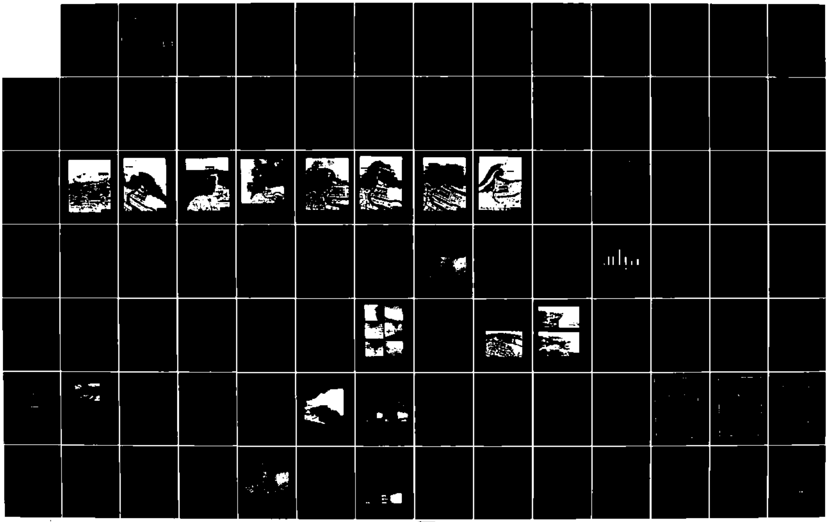

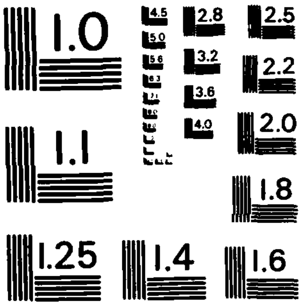


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# VERMILION HARBOR, OHIO

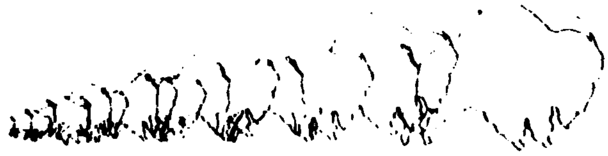
# CONDITION SURVEY REPORT



## STUDY OF THE IMPACT OF THE OFFSHORE BREAKWATER ON

A. MUNICIPAL WATER SUPPLY
B. SWIMMING AREA AND BEACHES
C. ICE JAM FLOODING
D. FREE - FLOW FLOODING
E. SEDIMENTATION
F. NAVIGATION
G. AESTHETICS





U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207



September 1982

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The federal project at Vermilion Harbor in Erie County, Ohio was originally constructed in 1839. The most recent improvements, made in 1973, consisted of construction of a cellular steel sheet pile detached breakwater about 300 feet offshore, and additional harbor dredging. Since construction of the breakwater, public concern has been expressed over the possible adverse impacts on the public welfare as a result of the breakwater construction. Seven possible adverse impacts were identified and studied. These impacts

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are discussed in this report. Based on the studies performed and the conclusions reached as a result of these studies, the Buffalo District recommended that no further consideration be given or action taken to mitigate these studied impacts. The district also recommended continuation of authorized harbor maintenance dredging.

ACKNOWLEDGEMENTS

This Impact Study on Vermilion Harbor, OH, was prepared through the efforts of many individuals on the Interdisciplinary Team within the Buffalo District and with input from personnel of other agencies and individuals. The Main Report was written for the most part by Mary C. Fabos and completed in the final stages by James Conley. Study management was performed by John Annoni, Michael Wojnas, and Jerrold Jurentkoff under the supervision of John Zorich.

Members of the Buffalo District Interdisciplinary Team who participated in the study include: Denton Clark and Joan Pope, Coastal Engineering; Philip Berkeley and Mary Jo Braun, Environmental Resources; and Stephen Yaksich, Water Quality Management.

A major portion of the technical investigations were performed by private consulting firms under contract to Buffalo District. The individuals involved are numerous and not easily identified. Therefore, recognition is provided by the names of their employers, as follows:

Tetra Tech, Inc.
Stanley Consultants

This report itself was produced through the efforts of many other Corps personnel, including the following:

| | |
|---|---|
| Roman Bartz | Chief, Drafting Section |
| Mattie Davis | CPT Operator |
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The Buffalo District Engineer, during the final phase of this report, was Colonel George P. Johnson; the Chief of Planning Division was Charles E. Gilbert; and the Chief of Engineering Division was Donald M. Liddell.

Finally, the efforts of other individuals who participated in the study and report preparation, but whose names have not been mentioned above, are gratefully appreciated.

CONDITION SURVEY

FOR

VERMILION HARBOR, OHIO

IMPACT STUDY OF

THE DETACHED BREAKWATER

ON

a. Municipal Water Supply

b. Swimming Areas and Beaches

c. Ice Jam Flooding

d. Free-Flow Flooding

e. Sedimentation

f. Navigation

g. Aesthetics

CONDITION SURVEY REPORT
FOR
VERMILION HARBOR, OHIO

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APPENDICES

Vermilion Harbor
Vermilion, Ohio

Impact Study of the
Detached Breakwater

MAIN REPORT

U. S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

CONDITION SURVEY REPORT
FOR
VERMILION HARBOR, OHIO
IMPACT STUDY OF
THE DETACHED BREAKWATER

# INTRODUCTION

## STUDY PURPOSE

The purpose of this study was to determine whether or not the detached breakwater at Vermilion Harbor, OH, is causing any adverse effects for which mitigation measures should be considered. The study was initiated in April 1977 in response to complaints from the Linwood Park Cottage Owners Association and other citizens concerned about specific subjects.

The Vermilion Harbor project is a Federally constructed facility whose purpose is to provide a safe harbor for recreational and commercial fishing craft. The latest Vermilion Harbor improvements were completed in July 1974, and consisted of channel widening and deepening and construction of a detached breakwater approximately 300 feet off the ends of the existing piers. Subsequent to this latest construction, there were repeated complaints that the breakwater is causing serious environmental, health, and recreation problems in the adjoining area. The purpose of this report is to present the results of the investigations undertaken to identify and develop feasible solutions to these problems based upon sound engineering, economic, environmental, and social considerations.

## STUDY AUTHORITY

Authorization for the study of impacts created by the detached breakwater in Vermilion Harbor, OH, is contained in ER 11-2-101 (15 May 1967). Chapter 4, Operation and Maintenance, details Feature 0.7, Condition and Operation Studies. This feature provides for " . . . reconnaissance surveys, detailed condition surveys, inspections, and studies to determine the physical condition and operating deficiencies of . . . , structures of projects operated and maintained by the Corps of Engineers and the dissemination of information relating thereto."

In addition to this Condition Survey, the Buffalo District has prepared a Detailed Project Report concerning mitigation of shore damages due to Federal navigation works at Vermilion Harbor. This Detailed Project Report was prepared under authority of Section III of the River and Harbors Act of 1968, PL 90-483, approved 13 August 1968, and is a companion report to this document.

The Federal Government initially authorized the construction of harbor improvements at Vermilion, OH, by the Rivers and Harbors Act of 1836. Continued improvements to the harbor were authorized by the Rivers and Harbors Act of 1875 and 1958. The existing project depth of 12 feet was first authorized for commercial vessels in the River and Harbors Act of 1875.

STUDY SCOPE

The scope of this study is to evaluate the impact of the detached breakwater on:

- The municipal water supply.
- Swimming areas and beaches.
- Ice jam flooding.
- Free-flow flooding.
- Sedimentation.
- Navigation.
- Aesthetics.

This report summarizes the studies performed to date and presents the conclusions reached by the District regarding the need for mitigation.

STUDY PARTICIPATION AND COORDINATION

The Corps of Engineers has coordinated efforts with the public to obtain accounts of harbor conditions tracing time, nature, and sources of the breakwater impacts. Public participation was also utilized to determine the historical behavior of ice formation in the harbor area.

Soon after construction of the breakwater in 1973, public controversy developed over alleged adverse effects of the detached breakwater. Individuals and groups wrote letters expressing their opinions on the breakwater and its impacts. The major concerns expressed were degradation of water quality and the loss of beach sand to the east of the breakwater. These concerns resulted in a Section 111 Reconnaissance Study being initiated in 1975.

A public meeting was held on 30 August 1977 at Vermilion High School to report on the outcome of the Section 111 Reconnaissance Study and the initiation of the Impact Study and the Companion Section III Detailed Project Report. As explained at the August 1977 public meeting, the Buffalo District selected Stanley Consultants to undertake this phase of the study to insure maximum objectivity of judgement in arriving at a conclusion regarding the breakwater impacts. The greatest concern the residents of Vermilion expressed was over the quality of the water at the beaches.

A second public meeting was held a year later at Vermilion High School on 31 August 1978. The purpose of that meeting was to present the results of Stanley Consultants' Impact Study. Of the general topics introduced, flooding due to ice jams received a substantial amount of discussion. Several individuals expressed the opinion that the detached breakwater promotes ice jamming at the mouth of the Vermilion River. This led to a discussion of

the Coast Guard's responsibility to and its past performance in the clearing of ice jams. The attending public was reminded that the Coast Guard's primary mission is not flood protection and that it cannot be depended upon to relieve future ice jams at Vermilion Harbor. Also discussed at length was the loss of beach to the west of the harbor piers. This impact is addressed in the previously mentioned Companion Section 111 Report.

Close coordination was maintained with several agencies during the preparation of this study. Both the Erie County Department of Health and the Ohio Department of Health were frequently used to obtain water quality data at Vermilion area beaches during the initial study. The Vermilion Port Authority was contacted to obtain information on channel conditions and past ice breaking operations, while the U. S. Coast Guard was contacted numerous times to provide information on its ice breaking responsibilities and method of operations for clearing ice jams in the harbor. Copies of correspondence were presented in previous Vermilion Harbor impact studies by Stanley Consultants and Tetra Tech. Pertinent correspondence is contained in Appendix A of this report. Additional correspondence concerning this report can be obtained in the library of the Buffalo District Office, at 1776 Niagara Street, Buffalo, NY 14207.

Continual coordination was maintained with all levels of Government - local, State, and Federal - to obtain information and to report study progress.

## PRIOR STUDIES AND REPORTS

Several studies and reports have been completed for various improvements at Vermilion Harbor. Two of these reports present results of studies done on the impacts of the offshore breakwater as related to the harbor area.

The Breakwater Impact Study of Vermilion Harbor, Ohio was completed April 1978 by Stanley Consultants for the Corps of Engineers, Buffalo District. The report presents results of a study on the impact of the detached breakwater on: (1) municipal water supply, (2) swimming areas and beaches, (3) ice jam flooding, (4) free-flow flooding, (5) sedimentation, (6) navigation, and (7) aesthetics. This report was previously sent to the principal study participants, and is available in the library at the Buffalo District Office, Ritter Public Library, Vermilion Port Authority, city of Vermilion and the Linwood Park Company Offices.

The Special Impact Study of Ice Jam Flooding, Vermilion Harbor, Ohio was completed in July 1980 by Tetra Tech for the Corps of Engineers, Buffalo District. Because this report has not been distributed for public review, it in included in its entirety as Appendix B to this document.

# THE STUDY AREA

GENERAL

This section presents information that will provide an understanding of the area's existing physical environment, and development of the Federal Harbor Project. The purpose of this section is to provide a frame of reference for subsequent discussions of needs and alternative solutions, together with their effects.

THE FEDERAL PROJECT

a. Location and Description

The Federal Project at Vermilion Harbor, located at the mouth of the Vermilion River in Erie County, OH, is approximately 37 miles west of Cleveland, OH and was originally constructed in 1839. The harbor is comprised of east and west approach channels, the lower 3,600 feet of the Vermilion River, and four artificial lagoons. A detached breakwater built in 1973 by the Federal Government shelters the approach channels during moderate wind and wave conditions and reduces wave and surge action in the harbor. Four lagoons, constructed on the east side of the river by private interests, have depths averaging 4 feet below the Lake Erie Low Water Datum (LWD) of 568.6 feet on the International Great Lakes Datum of 1955. Figure 1 shows the harbor layout and location.

Several beaches are located near the Federal Project at Vermilion Harbor. They are Vermilion City Beach, located about 200 feet to the west of the harbor entrance; and Lagoons, Linwood, and Nakomis Beaches, located east of the harbor entrance. The locations of the beaches are shown on Figure 1. Sherod Beach, 1.5 miles to the west of the harbor, was also considered in the study.

b. History of Vermilion Harbor Project

Until the Federal Government began construction of the original two jetties at the mouth of the Vermilion River in 1836, less than 2 feet of water flowed over the bar at the Vermilion River mouth. The development of the harbor from a natural river state to the present harbor configuration is summarized below.

CHRONOLOGY OF HARBOR IMPROVEMENTS

1836 - Rivers and Harbors Act authorized the U. S. Army Corps of Engineers to develop a harbor at Vermilion. Constructed in 1839 were parallel piers, built 125 feet apart, extending lakeward to the 10-foot depth contour.

1874-1878 - Piers extended to the 12-foot depth contour.

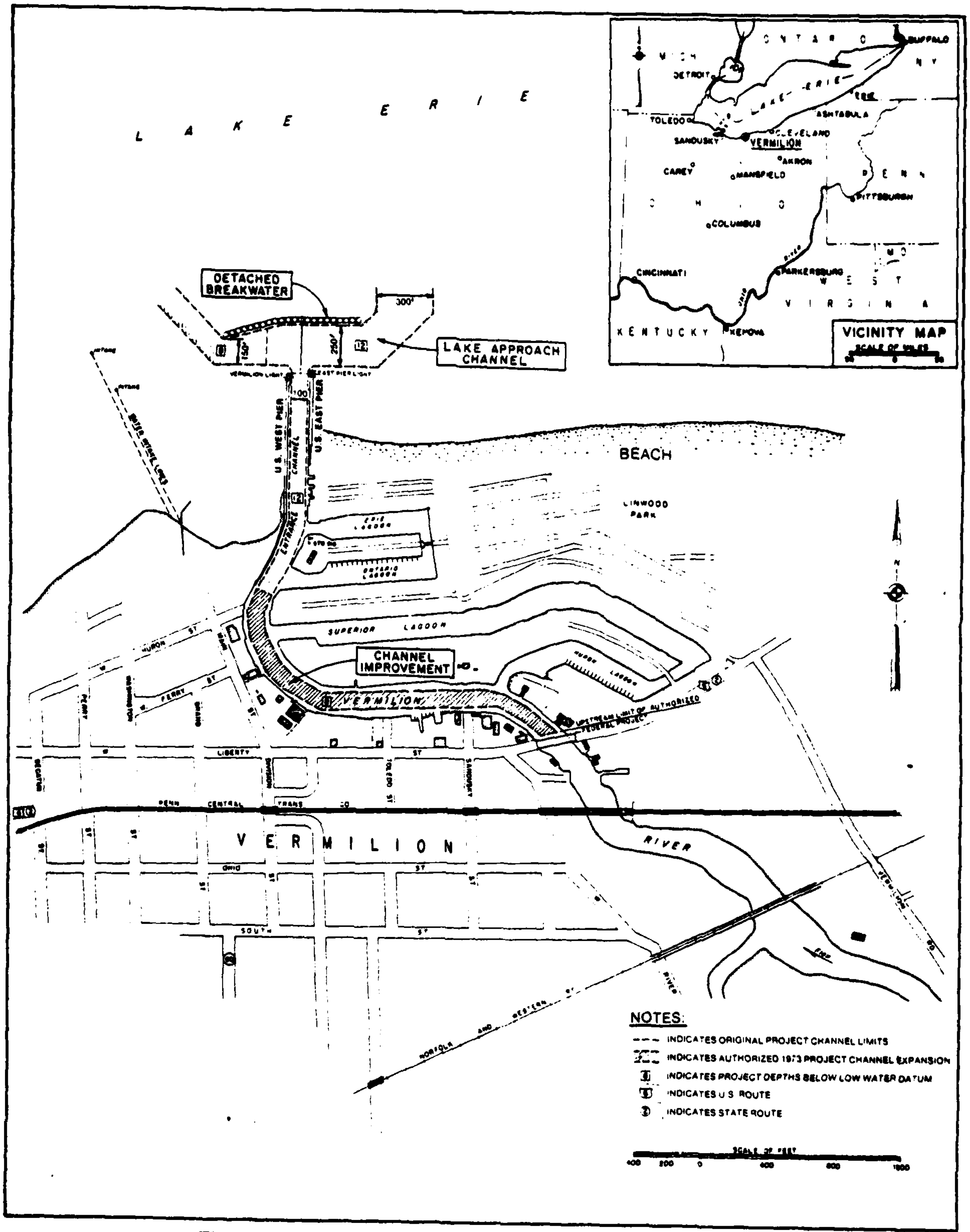



**Figure 1 • VERMILION HARBOR LAYOUT & LOCATION**

1875 - Rivers and Harbors Act authorized an increase in channel depth to 12 feet and an extension of the channel upstream to about 1,330 feet from the outer end of the entrance piers. Construction was completed in 1878.

1905 - Rivers and Harbors Act authorized pier repairs and replacement of the timber superstructure with heavy stone. Work was completed in 1914.

1933 - Erie, Ontario, Superior, and Huron Lagoons completed by private interests.

1945 - (3 May) The public, in a hearing at Vermilion, requested that means be provided for entering the harbor under extreme weather conditions.

1958 - Rivers and Harbors Act authorized improvements to the entrance and channel of harbor, as proposed in the 1956 Report on Vermilion Harbor, Ohio, for Navigation (Survey) by the Corps of Engineers.

1968-1969 - Model studies of proposed harbor improvements at Waterways Experiment Station, Vicksburg, MS.

1971 - General Design Memorandum, Vermilion Harbor, Ohio, completed by the Corps of Engineers, describes the proposed entrance and channel improvements, including:

- A detached "T-type" breakwater.
- Excavation of 9,000 cubic yards of earth.
- A westerly lake approach channel.
- An easterly lake approach channel.
- A river channel extension.

1973 - Construction of the latest Vermilion Harbor project including the detached "T-type" cellular breakwater and associated channel improvements.

1974 - Citizen complaints received by Corps of Engineers regarding possible effects of the new breakwater.

June 1974 - Emergency dredging 5,900 cubic yards, from east side of the entrance channel disposed of on west side of west pier.

February 1975 - Emergency dredging 3,000 cubic yards, at east side of the entrance channel.

December 1975 - Maintenance dredging 5,000 cubic yards, outer portion of breakwater, disposed of in open-lake.

December 1978 - Maintenance dredging 3,700 cubic yards, between the breakwater and end of the piers open-lake disposal.

May 1979 - Sand Pumping Demonstration Program - Artificial transport of approximately 2,500 cubic yards of sand from the East Pier fillet to eastern end of Linwood Beach.

October - November 1979 - Maintenance dredging 33,000 cubic yards, between the piers and upriver to the upstream limit of the project. Open-lake disposal and confined disposal at Lorain Harbor.

Except for minor alterations during pierhead construction, the position of the lakeward ends of the jetties has not changed since 1878. Besides making frequent and extensive repairs to both piers, between 1907 and 1914 the Federal Government replaced the entire timber superstructure with heavy stone, raising the elevation of the piers to 6.5 feet above low water datum.

The Rivers and Harbors Act of 1958 authorized overlapped arrowhead breakwaters, which were to be built at a distance of about 500 feet lakeward of the outer end of the east pier with a new entrance 150 feet wide, as shown in Figure 2.

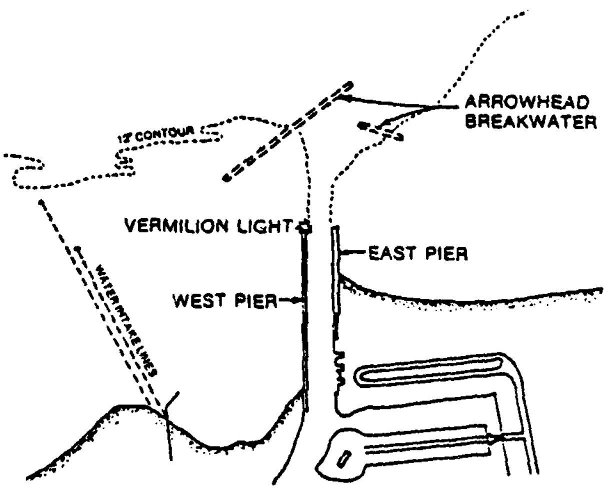



Figure 2 • BREAKWATER AS PROPOSED IN SURVEY REPORT OF 1956

This proposed plan of improvement was discussed with representatives of both the commercial and recreational boating interests. The breakwaters would provide a protected area about 500 feet long in which vessels could be maneuvered for entry between the existing piers with little interference by waves and currents. The planned improvement of the river channel further upstream would provide an easier approach to the lagoons.

A model study of this authorized plan was conducted at the Waterways Experiment Station in 1967. The model study, limited to investigating the effects of various structures on wave action, showed that the open arrowhead type of breakwaters did provide some reduction in wave action. However, there were indications that a disproportionate increase in the length of the breakwaters would be required to reduce wave heights to satisfactory levels in the harbor. After reviewing these satisfactory plans that varied length and alignment, the Vermilion Port Authority requested selection of a single breakwater located parallel to the shore and about 300 feet north of the existing pier ends, for the following reasons:

- Increased navigation clearance during peak use time and severe weather conditions.
- Additional clearance for discharge of ice at breakup time.
- Safe and easy maneuverability for the Coast Guard icebreaker.

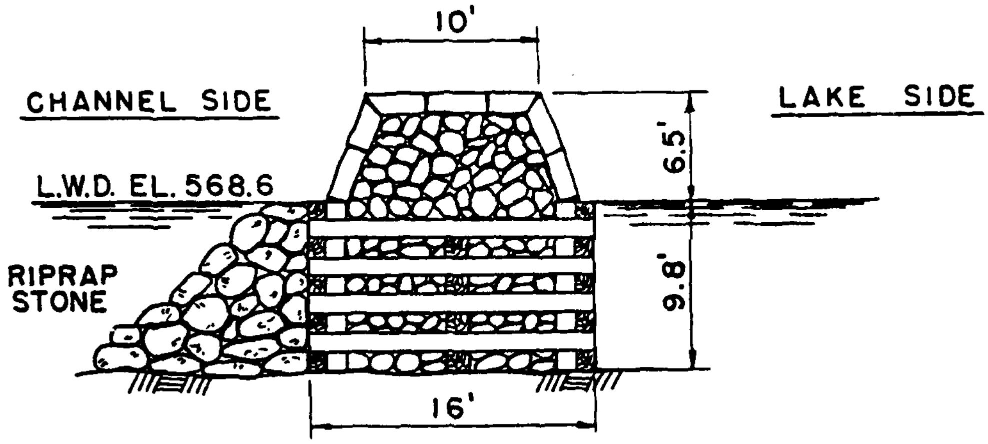
In 1973, the Federal Government constructed the breakwater, a "T-type" cellular structure, and extended the Federally maintained river channel to a point 3,600 feet upstream from the east entrance pier. The 864-foot long breakwater is aligned in an east-west direction. The structure consists of 22 35-foot diameter circular steel caisson cells with overlapping arcs (Figure 3). After sheetpiles were driven into bedrock, the cells were filled with locally available granular material, covered with a 2-foot thick reinforced concrete cap, and had the appropriate cleats, light poles, and ladders installed. The top of the breakwater is 10 feet above LWD.

During the construction period, approximately 20,000 cubic yards of sediment and 5,700 cubic yards of unclassified material were dredged from the lake approach entrance channel, classified suitable for open-lake disposal, and deposited in the open-lake dump zone 2-1/4 miles north of the harbor. Sediment dredged from the river channel was classified unsuitable for open-lake disposal by the Federal Water Pollution Control Administration (now the U. S. Environmental Protection Agency) and deposited in an upland disposal site located about 3.5 miles south of Vermilion.

## NEARSHORE WATER CIRCULATION

The nearshore Lake Erie currents near Vermilion are primarily influenced by the wind, the bottom topography, and inflows from tributaries. The flow in the Vermilion River is highly variable, and in fact often reverses due to small, short-term lake level fluctuations. Small changes (2 to 3 inches) in lake level commonly occur in 15 to 30 minutes. An increase in lake level stops river flow or pushes water upstream. Eventually, the river rises to a level above the lake and forces flow out of the mouth.

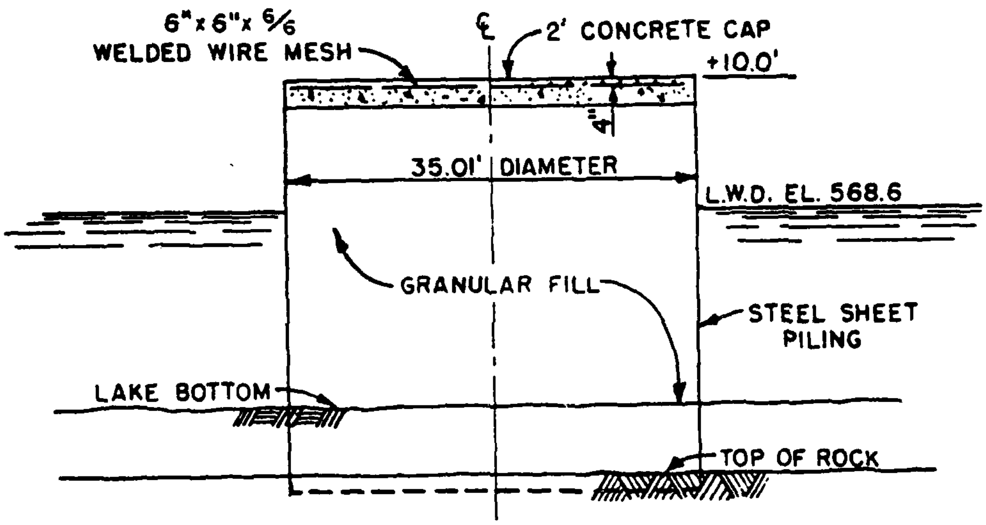
Water from the Vermilion River is generally warmer than water from Lake Erie and, therefore, floats over the lake water. This effect was documented by Stanley Consultants and is shown in Figure 4.




## SECTION OF EAST PIER

WEST PIER SIMILAR BUT OPPOSITE HAND
(BUILT 1836 - 1839, REBUILT 1906 - 1914)

REHABILITATION OF 450 FEET OF WEST PIER AND 230 FEET OF EAST PIER INITIATED IN JUNE 1964 AND COMPLETED IN OCTOBER 1964. (TOP ELEVATION RAISED TO 6.5 FEET ABOVE L.W.D. AND RIPRAP STONE PLACED ON LAKE SIDE.)




## DETACHED BREAKWATER

(BUILT 1973)

**Figure 3 · DESIGN OF PIER AND BREAKWATER STRUCTURES, VERMILION HARBOR**

VERMILION HARBOR, OHIO

U.S. ARMY ENGINEER DISTRICT BUFFALO

30 SEPTEMBER 1977

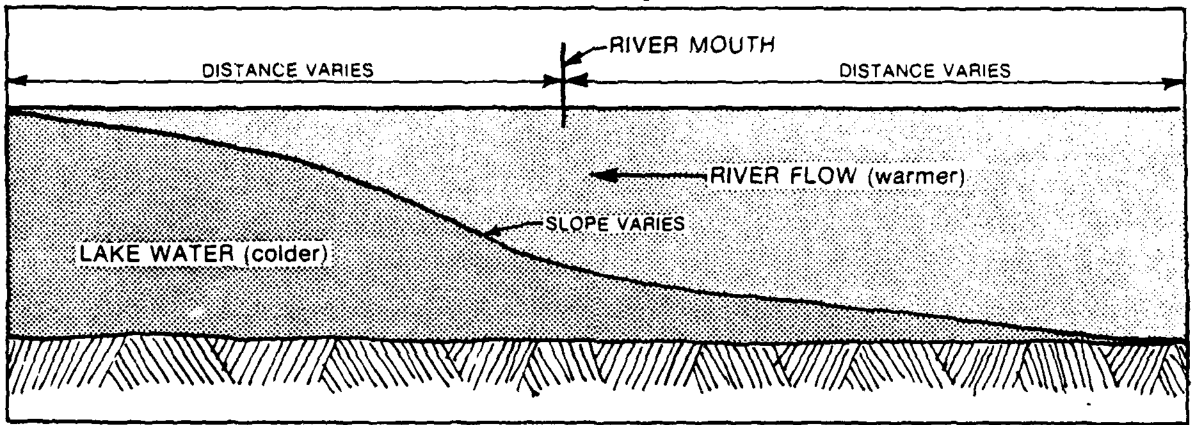



**Figure 4 • EFFECT OF RIVER ENTERING THE LAKE**

Lake Erie water was often found in the bottom few feet of water, 1,000 feet or more upstream of the mouth of the Vermilion River. This gradual increase of colder lake water creates a "wedge" effect, the wedge being highly variable and depending on river flow, lake currents, and temperature effects. The resulting mixture of lake and river water creates a "plume" (an area of influence) as it flows into the lake. It is the behavior of this plume which is of importance.

It is readily apparent that the detached breakwater has to some degree altered the currents and, therefore, the behaviour of the river plume. The critical question is whether the breakwater has resulted in river water reaching the beach areas or the municipal water supply intake more frequently, or with less dispersion or dilution.

a. Winds

Wind direction closely parallels the surface lake current. Therefore, to facilitate comparison of conditions before and after the construction of the breakwater, significant wind classifications will be summarized and analyzed.

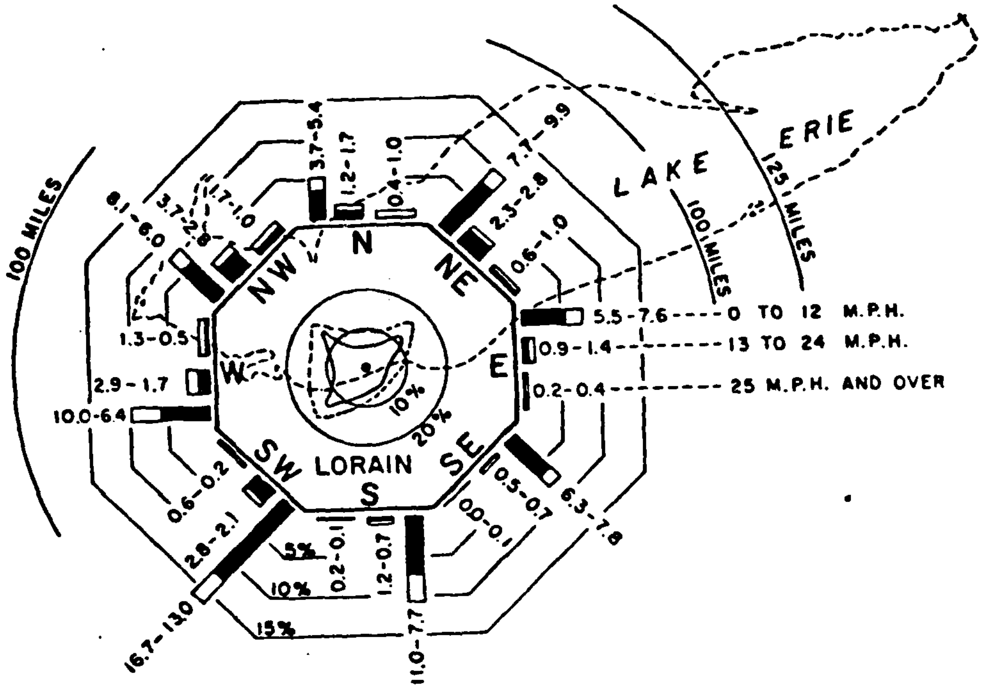
Three wind classifications have significant effect on currents:

- North through northwest winds - direction of storms and some light to moderate winds.

- East through northeast winds - direction of storms and light to moderate winds.

- West through southwest winds - prevailing (35-40 percent) winds for Vermilion.

A wind rose diagram for the nearest weather station at Lorain, OH is shown in Figure 5. Each of the three groups contain conditions relative to beach pollution and the quality of water intake.




WIND DIAGRAM FOR LORAIN HARBOR, OHIO

NOTES

INDICATES DURATION FOR ICE-FREE PERIOD (MAR. TO DEC. INCL.) IN PERCENT OF TOTAL DURATION.

INDICATES DURATION FOR ICE PERIOD (JAN. TO FEB. INCL.) IN PERCENT OF TOTAL DURATION.

INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING ICE-FREE PERIOD.

INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING COMBINED ICE AND ICE-FREE PERIODS.

FIGURES AT ENDS OF BARS INDICATE PERCENT OF TOTAL WIND DURATION FOR ICE-FREE PERIOD AND COMBINED ICE-FREE AND ICE PERIODS, RESPECTIVELY.

WIND DATA BASED ON RECORDS OF THE U.S. COAST GUARD AT LORAIN HARBOR, OHIO FOR PERIOD 1 JAN. 1938-31 DEC. 1971

Figure 5

North Through Northwest - Wind from these directions vary widely in intensity from severe storms to light moderate summer breezes. Photos 1 and 2 show the river plume movement under winds of 6 to 8 knots, and provides a good comparison of the breakwater effect. It is apparent that the breakwater has presented an obstruction to the plume, and prevents a portion of the water from moving north. With the breakwater in place essentially all of the river water remains in the vicinity of the beaches (Photo 2). However, even before the breakwater, the majority of the river flow appeared to turn and flow toward Lagoons Beach (Photo 1). It is evident from this comparison of Photos 1 and 2 that water from the Vermilion River is deflected toward the beach areas with or without the breakwater for winds from the north through northwest.

East Through Northeast. Wind from these directions ranges in intensity from light summer breezes to severe storms. The passage of frontal systems from these directions frequently results in winds of 13 to 17 knots for 2 to 3 days. Photos 3-5 provide a comparison of the pre and postbreaker conditions for winds from the east through the northeast. Prior to the construction of the breakwater, river water veered to the west as shown in Photos 4 and 5. Stronger winds (Photo 5) force the plume more toward the shore. Comparison of Photos 3 and 4 reveals that the breakwater inhibits the northerly flow of the current, causing the river plume to veer more sharply towards the west. It is apparent from the photos that the surface river water moves toward the vicinity of the water intake under east through northeast winds for both pre and post breakwater conditions.

West Through Southwest. Winds from these directions are the prevailing winds. Photos 6 through 8 show the effect on the plume by these winds in pre and postbreakwater periods. Photo 7 shows the Vermilion River water moving essentially offshore (north) during moderate southwesterly winds. A comparison of Photos 7 and 8, taken during similar wind conditions, indicates that the breakwater appears to force river water along the Lagoons and Linwood swimming areas.

Field data was obtained during the summer of 1977 for several southwesterly wind periods. From this data, it was discovered that the river plume generally travels to the east along the shore. Water at a depth of 8 feet was observed to travel in the same direction as the surface water, but at speeds of up to 50 percent lower than the surface water. Upwelling of the deeper water occurs offshore of Lagoons and Linwood Beaches. This results in increased dilution of the river water. Dye and conductivity tests verified that significant dilution of river water occurs prior to reaching the swimming areas.

b. Currents

Based on the studies performed by Stanley Consultants in 1977 and 1978, the following conslusions regarding the general effects of the offshore breakwater on currents on the vicinity have been drawn. Currents in Lake Erie consist of very weak, natural flows of water through the Great Lakes system, immeasurably slow because of the large cross section of the central basin of the lake. Circulation is controlled by the wind, and reversals are

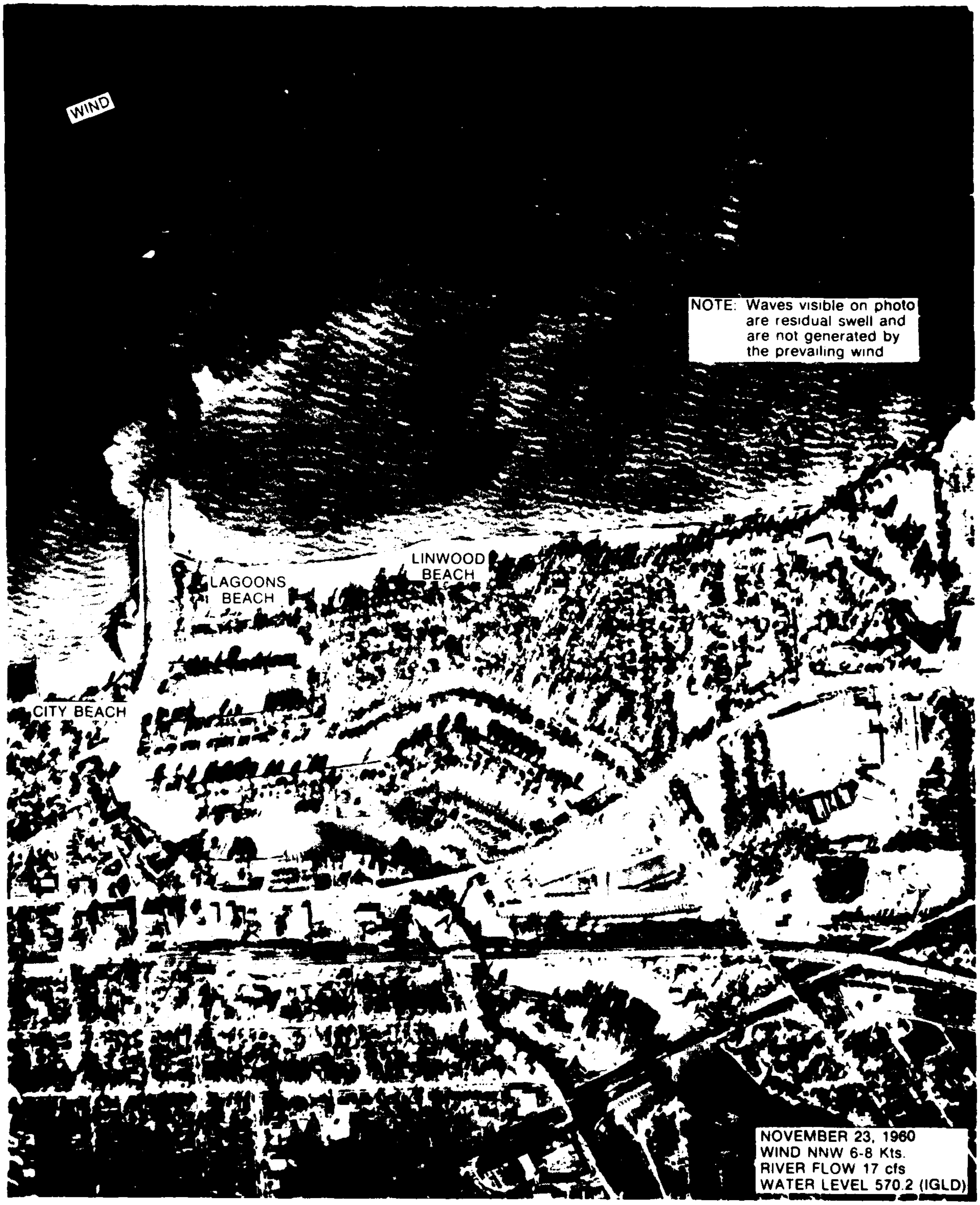



Photo I •PREBREAKWATER - SHOWS INTERMITTENT RIVER FLOW WITH SOME INFLUENCE ON LAGOONS BEACH.

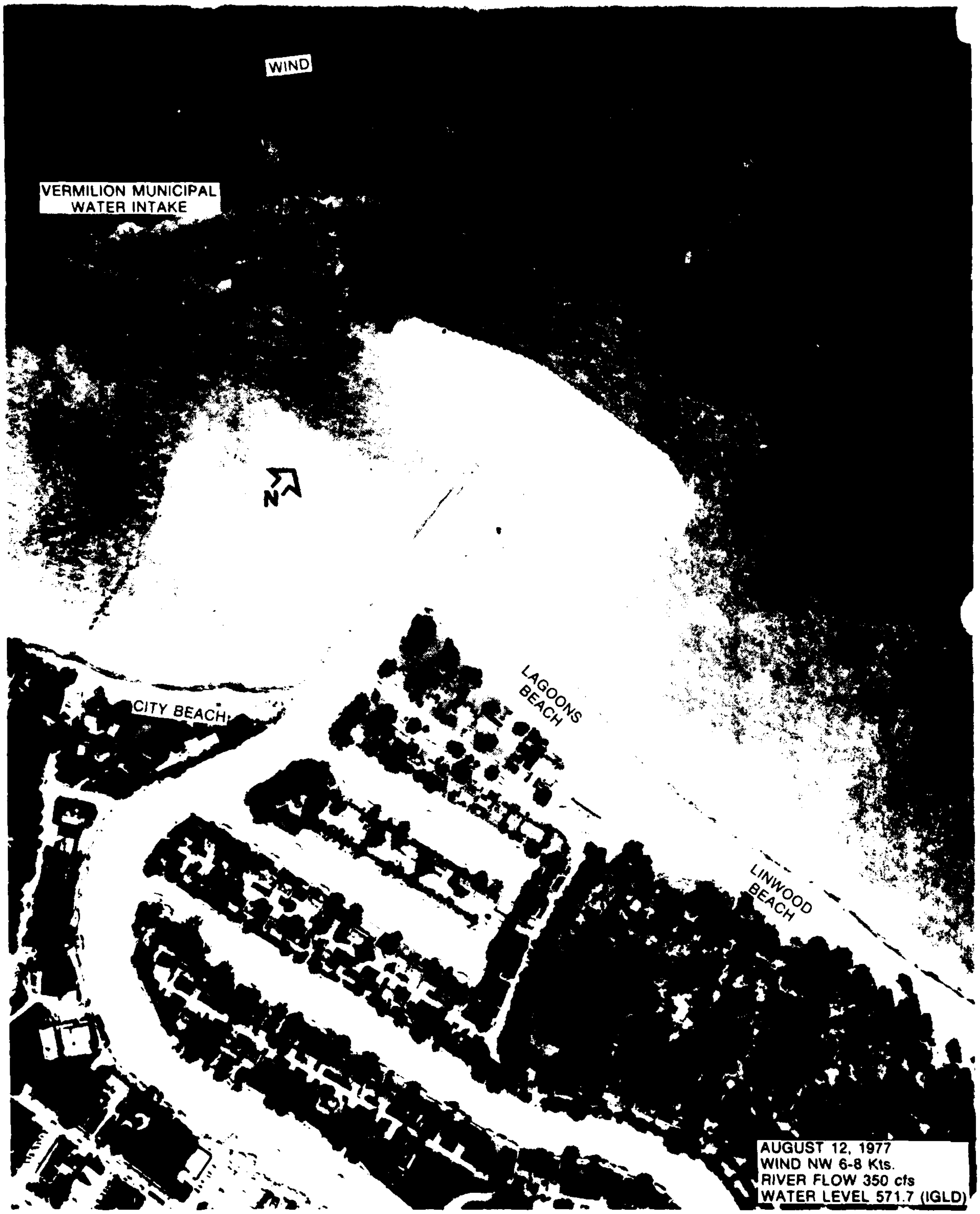



Photo 2 • BREAKWATER DEFLECTS FLOW - EFFECT ON BEACH AREAS SIMILAR TO PREBREAKWATER CONDITIONS.

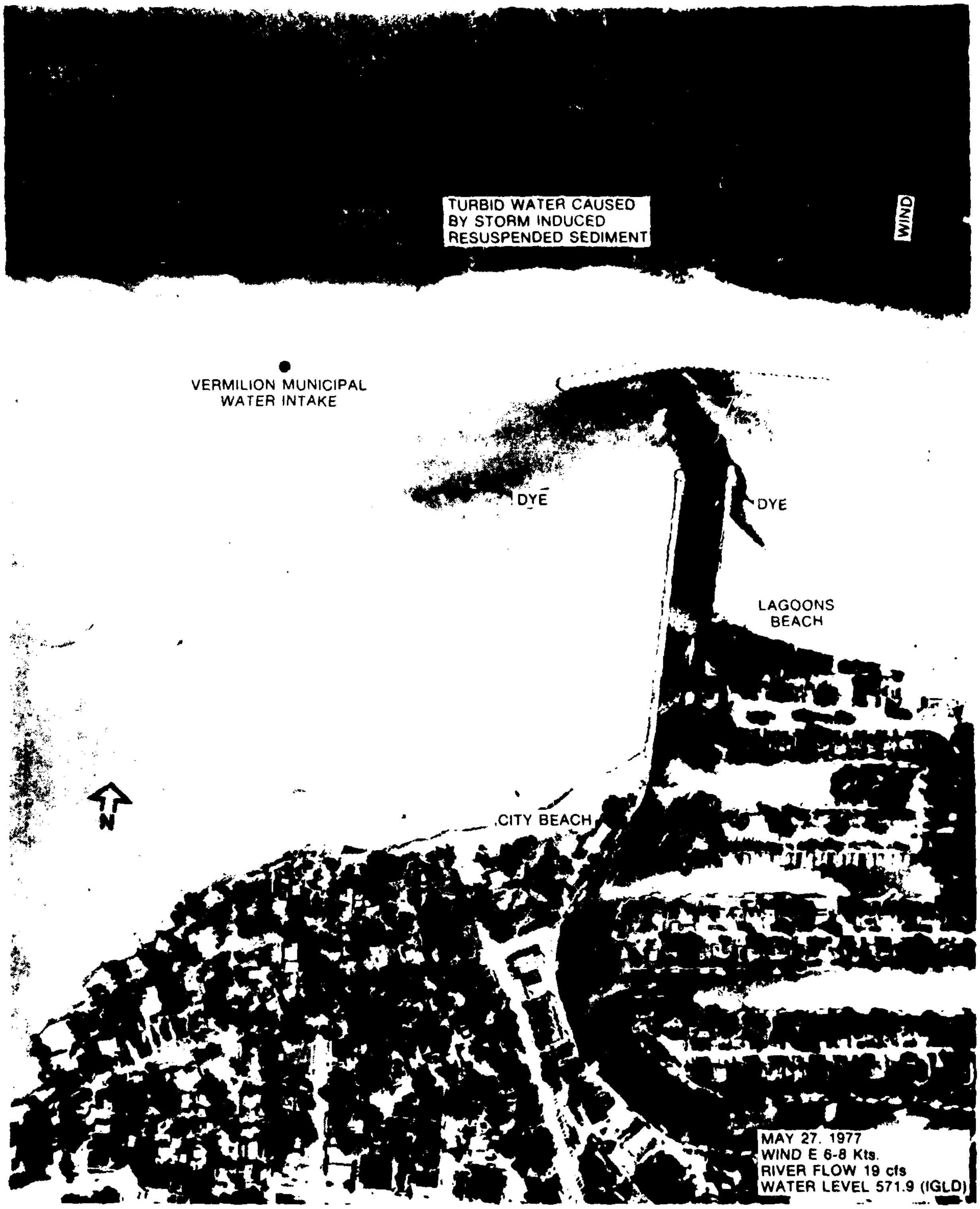



Photo 3 • BREAKWATER DEFLECTS RIVER PLUME BUT HAS LITTLE EFFECT ON AREA OF INFLUENCE.


Photo 4 • SHOWS SOME INFLUENCE ON WATER INTAKE.

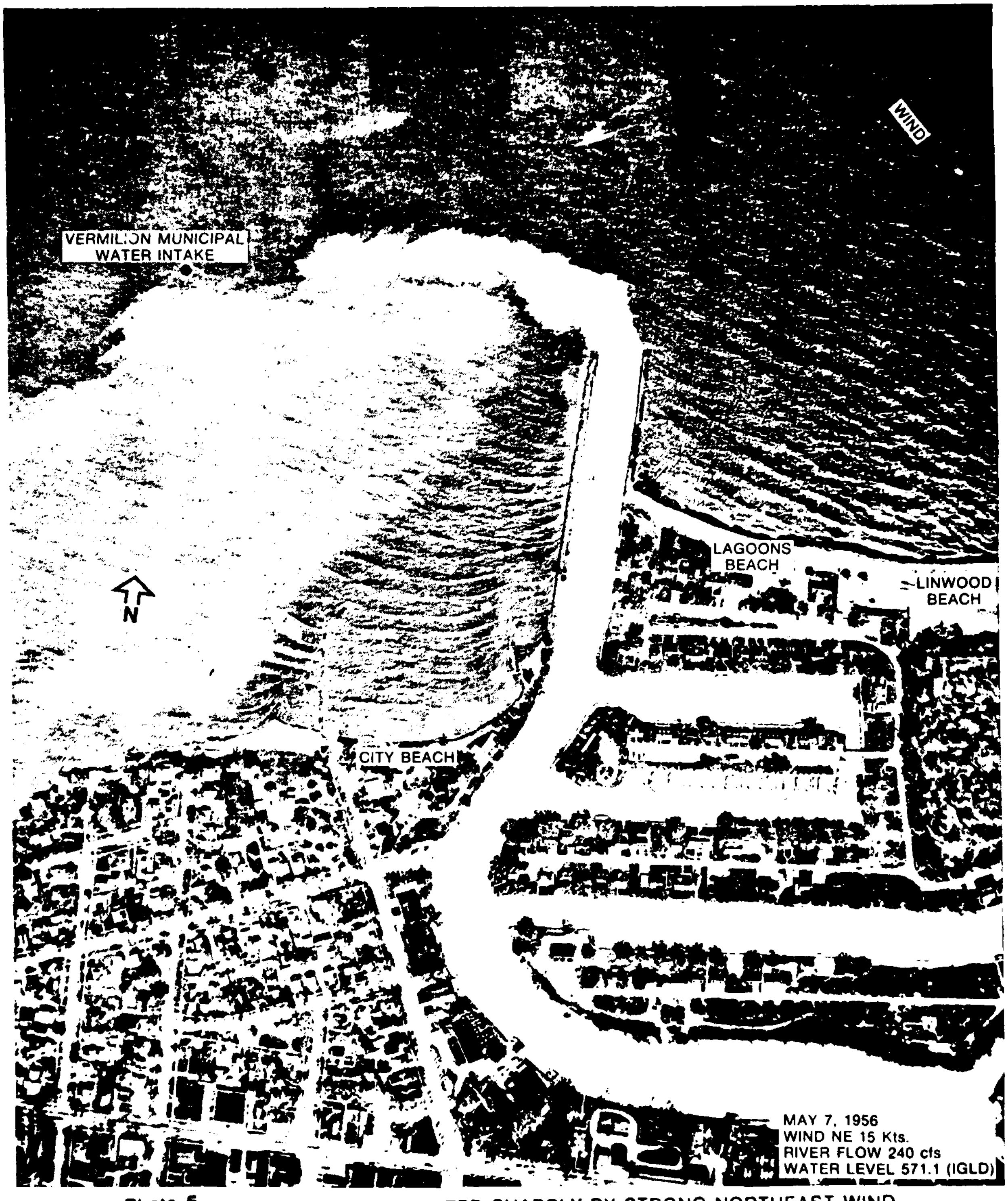



Photo 5 – RIVER PLUME DEFLECTED SHARPLY BY STRONG NORTHEAST WIND


Photo 6 • BREAKWATER DEFLECTS CURRENTS TOWARD THE EAST - SOME INFLUENCE ON LAGOONS AND LINWOOD BEACH.

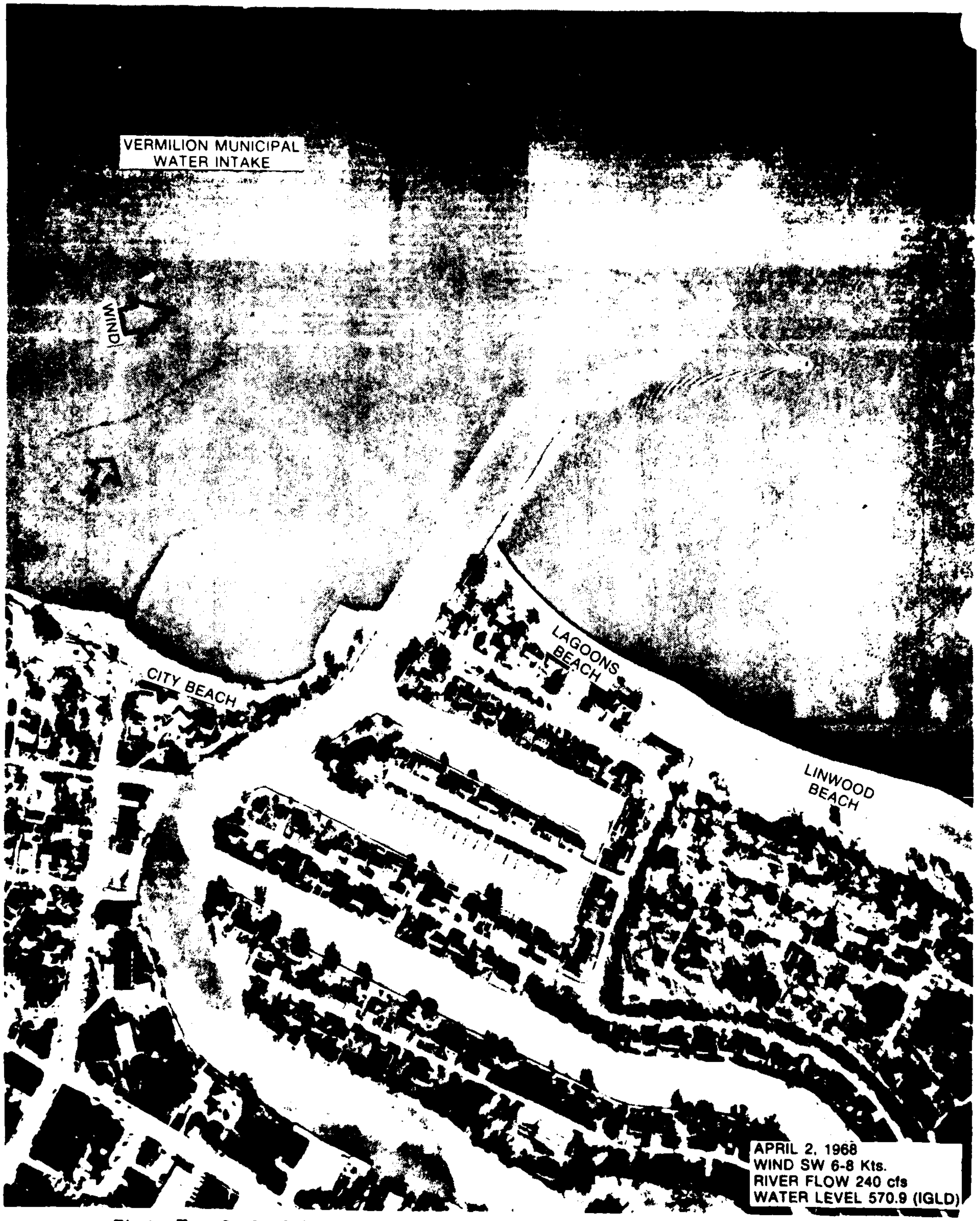



Photo 7 • SHOWS RIVER PLUME MOVING NORTH UNDER SOUTHWEST WIND.

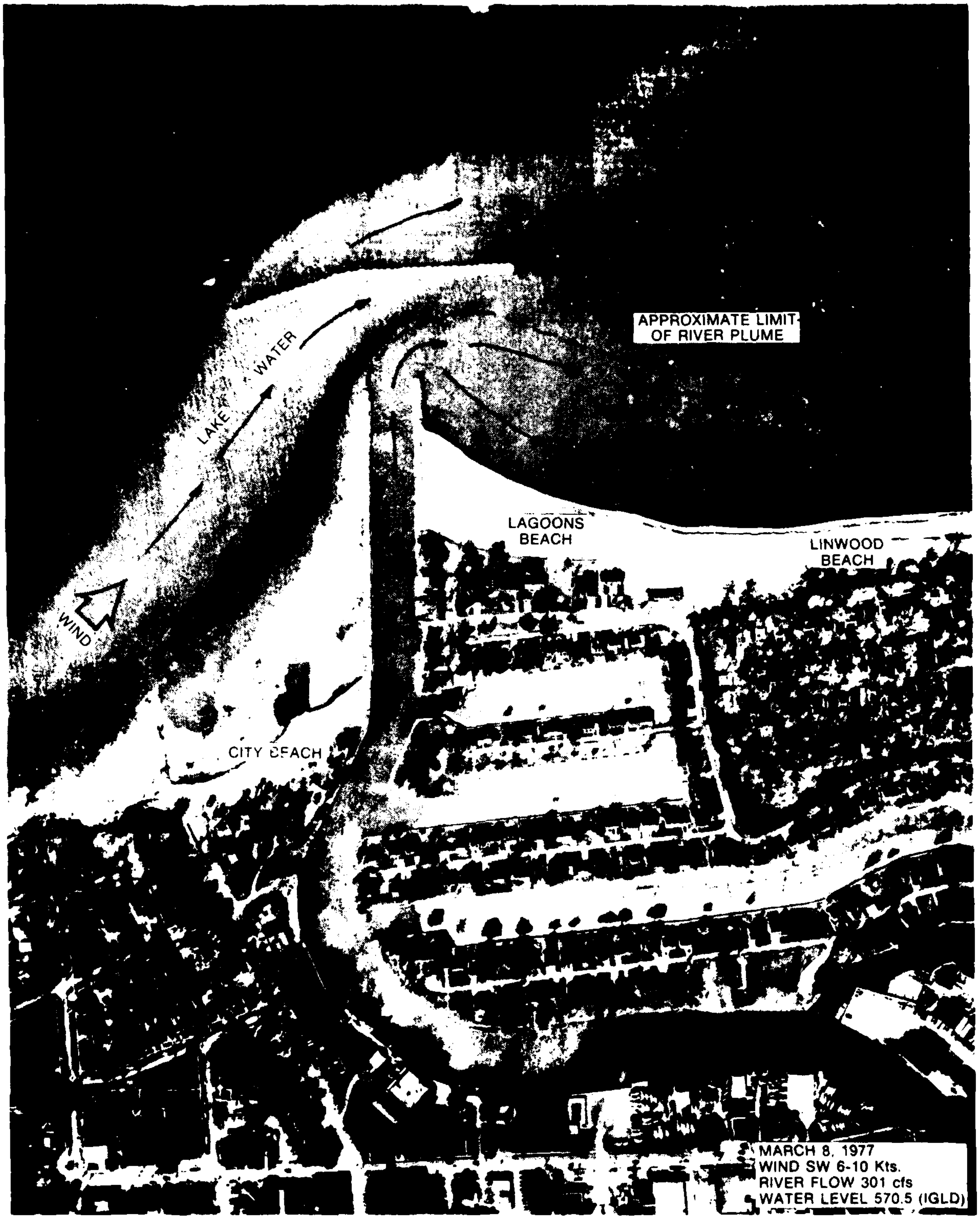



Photo 8 • SHOWS RIVER WATER MOVING ALONG BEACH AREAS.

common with wind shifts. The predominant surface water movement is eastward due to prevailing winds, with the wind-driven currents achieving velocities of up to 2 feet per second.

The preceding discussion of winds points out that the breakwater has had measurable impacts on currents in the nearshore Vermilion area.

The effect of the breakwater is particularly evident during the prevailing southwest winds. River water is diverted toward the Lagoons and Linwood Beaches particularly during light to moderate winds. Average speeds of these currents indicates that the river water will reach the Lagoons Beach swimming area in 60 to 90 minutes (somewhat less if river flow is high). During this time, significant dilution and dispersion takes place. Conductivity measurements taken during low to moderate river flow and southwest winds showed a high range of mixing characteristics, due to variations in river flow and wind conditions.

During light to moderate northeast wind conditions, the river water is diverted and moves westerly, parallel to shore, and then toward shore under the influence of the nearshore currents. This pattern results in river water being transported to the vicinity of the water intake. (During strong winds, river water would reach this area without the breakwater.) River water would reach the intake in 30 to 60 minutes, however, conductivity measurements at the intake failed to identify river water, indicating that high dilution was occurring. Although high river flows with easterly winds were not encountered during the study period, it is expected that very high flows would produce a measurable river effect at the intake. The physical diversion of water by the breakwater results in a more direct path to the intake with less dilution and dispersion. No other significant effects of the breakwater on currents under northeast wind conditions are apparent.

During north and northwest winds, the breakwater creates some diversion of northerly flowing river discharge. However, onshore lake currents bring the river water back to shore with or without the breakwater.

In conclusion, the breakwater has diverted river flow and altered current patterns in varying degrees for a variety of environmental conditions. Analysis of changes in current speeds has not been possible due to lack of quantitative baseline data.

# EVALUATION OF IMPACTS

## GENERAL

The most recent modifications to the small-boat harbor at Vermilion were made in 1973. These modifications consisted of construction of a cellular steel sheet pile detached breakwater about 300 feet offshore from the lakeward ends of the existing harbor piers, and additional harbor dredging. Since the construction of the breakwater, public concern has been expressed over the possible adverse impacts on the public welfare as a result of the breakwater construction.

Seven possible adverse impacts attributable to the offshore breakwater were identified and studied for this report. The following sections discuss these impacts, present a summary of the analyses performed to evaluate the effects of the breakwater on each, and provide the conclusions reached by Buffalo District regarding the need for mitigation of these impacts.

# MUNICIPAL WATER SUPPLY

## INTRODUCTION

Since completion of the offshore breakwater, Vermilion residents have made complaints that the municipal water supply has been contaminated. These complaints have indicated specific times when the water was bad, and also expressed feelings that the general long-term quality has been lowered. Color, turbidity, taste, and odor problems were mentioned. The purpose of this investigation is to determine what effects, if any, the offshore breakwater, completed in late 1973, has had on the quality of water at the municipal intake. As shown on Figure 1, page 5, the intake structure is located approximately 1,200 feet from shore, and 1,000 feet west of the piers, at a depth of 7 feet below low water datum of 568.6 (International Great Lakes Datum - 1955). The total water depth at the water intake is 11 feet below low water datum.

The three primary factors affecting the quality of the municipal intake are location of the intake, water quality of the Vermilion River, and lake currents.

## WATER QUALITY

Water entering the Vermilion municipal intake is affected by the interaction of lake currents with Vermilion river flow and quality. During most periods, the supply water is essentially Lake Erie water with little effect from the river. During occasional high river flows, more turbid river water arrives at the intake.

The most severe water problems occurred in February 1975. The water appeared "dirty" coming out of household taps but was perfectly safe, according to the Erie County Board of Health. It has been reported by the Ohio Environmental Protection Agency that the primary cause of the turbid water in the distribution system involved operational difficulties at the water treatment plan in response to the high turbidity of the intake water. It is the incidence of the high turbidity water at the intake, however, that is of importance to this study.

The most significant factor affecting the quality of water at the intake is the location of the intake. Because the water intake is approximately 1,200 feet from shore at a depth of 7 feet below LWD, it is sufficiently close enough to allow the quality of the river water to affect water quality, both before and after construction of the breakwater.

Because of the location, water quality is dependent on the quality of Vermilion River discharge, the quality of Lake Erie water, and the transport and mixing of these two waters.

Variations in both the seasons and weather produce an effect upon water quality at the intake. Analysis of water quality parameters measured at the intake shows overturn and stratification periods which occur from the heating and cooling of the lake. During overturn periods, turbidity and specific conductivity of the intake waters increase due to resuspension of benthic materials and mixing of deep and shallow waters. During summer stratification, low turbidities and low specific conductivities prevail. During summer stratification, low turbidities and low specific conductivities prevail. During the summer months, the intake level is near the photic zone and phytoplankton may affect intake water quality by increasing turbidities. Some species of phytoplankton are also responsible for taste and odor problems in water supplies.

During the winter, freezing near or around the intake may contribute to changes in intake water quality. The effect of lake currents on river water flow and dispersion is greatly reduced when ice cover is present.

Pollution affects the quality of the river water in the form of pathogenic organisms. These pathogens originate from several sources, such as undisinfected sewage effluent, wet weather sewer overflows, and small craft sanitary discharges. Lake water, besides being affected by a similar set of pollutant sources, also has the additional burden of industrial discharges and resuspended bottom sediments.

Water quality standards for Lake Erie waters of the State of Ohio are contained in Part 3745-1-11 of the Ohio Administrative Code. The following general water quality standards apply to all surface waters of the State of Ohio, including mixing zones. By Code, these water shall be:

a. Free from suspended solids or other substances that enter the waters as a result of human activity and that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life;

b. Free from floating debris, oil, scum, and other floating materials entering the waters as a result of human activity in amounts sufficient to be unsightly or cause degradation;

c. Free from materials entering the waters as a result of human activity producing color, odor, or other conditions in such a degree as to create a nuisance;

d. Free from substances entering the waters as a result of human activity in concentrations that are toxic or harmful to human, animal, or aquatic life and/or are rapidly lethal in the mixing zone;

e. Free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growth of aquatic weed and algae.

The primary source of pollutants that might affect the quality of water around the municipal intake is the Vermilion River discharge. The parameters analyzed to detect these pollutants were water temperature, specific

conductivity, turbidity, and fecal coliforms. Water temperature was selected as one of the parameters because river water is a few degrees warmer than lake water. Specific conductivity, a measure of dissolved solids, is higher for the river than the lake. Turbidity, a measure of suspended solids, was analyzed because high turbidity rates have been associated with intake water quality problems, as well as Federal drinking water standards. Fecal coliforms are analyzed because they are an indicator of pollution.

To determine how much, if any, of the fluctuation in the water quality was due just to the lake, similar data were analyzed for Elyria, Ohio. Elyria's intake, less than 10 miles east of Vermilion, has no breakwater nor river discharge, sits about the same distance to the shore (1,100 feet), and is slightly deeper (11 feet).

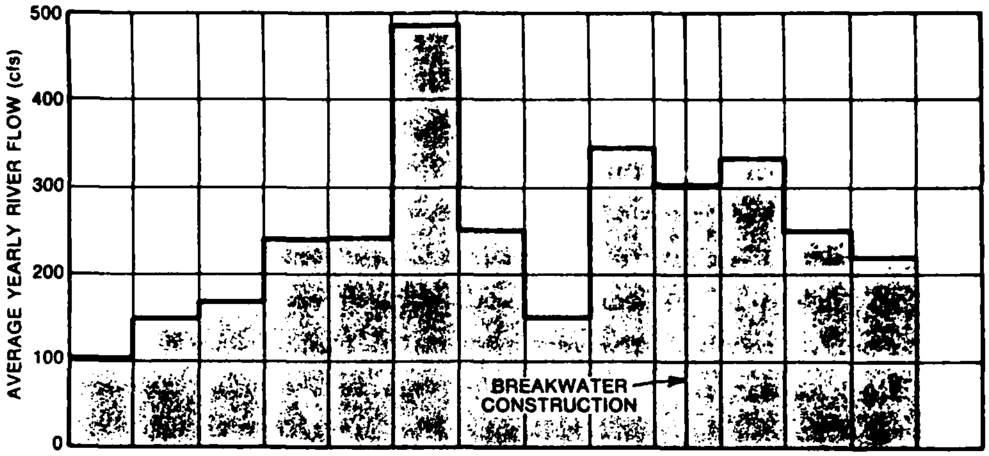
The quality data for Elyria exhibited significantly different values and trends than did the Vermilion data, indicating that the Vermilion River does indeed impact on the quality of Vermilion's municipal water supply.

A limited amount of Vermilion River water quality data for the period 1965 through 1977 were available for use by Stanley Consultants at the time of their study. These data indicated that the primary source of pollution in the river is runoff from upstream agricultural areas which add polluted sediments to the river. Estimated annual sediment load in the river varies from 36,000 tons to 300,000 tons per year. The Federal drinking water standard is less than 4 colonies of fecal coliforms per 100 milliliters. The data gathered indicated that fecal coliforms in the river were quite high at 200 to 1,000 colonies per 100 milliliters. In this instance, however, fecal coliforms are a poor indicator of human pollution. Animals are responsible for most of the fecal coliforms and values near the maximum range occurred during rainfall-runoff events.

ANALYSIS OF WATER QUALITY

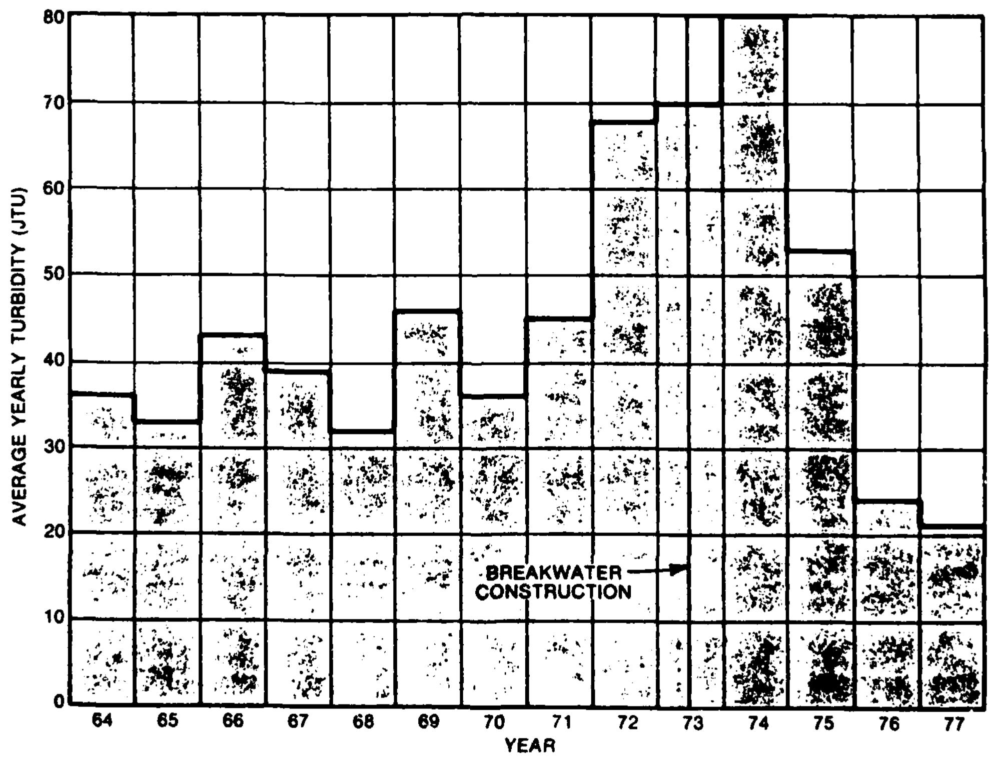
After reviewing the available data, turbidity was chosen as the clearest indicator of quality fluctuations in the intake water. Turbidity is also the parameter used for quality control within the water treatment plant. A graph of average annual turbidity versus time for the Vermilion water intake is presented on Figure 6. There is a period of high turbidity from 1972 through 1975 where the average annual turbidity is double that in the period 1964 through 1971. In 1976 and 1977, the average yearly turbidity dropped to levels below those recorded prior to 1972. An analysis of specific conductivity data shows relatively stable readings for 1968 through 1971 and higher specific conductivity for 1972 through 1975 corresponding to the high turbidity period. Specific conductivity data for 1976 and 1977 at the intake are not available.

Average yearly river flow is also shown on Figure 6. It is clear that the river flow was appreciably higher during the period of 1972-74, corresponding to the highest turbidity period. This indicates that the river has had a significant influence on intake quality, both before and after the breakwater.




HISTORICAL TRENDS - RIVER FLOW

SOURCE: U.S. GEOLOGICAL SURVEY WATER SUPPLY PAPER




HISTORICAL TRENDS - TURBIDITY AT WATER INTAKE

SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY, STORET

Figure 6 - HISTORICAL TURBIDITY AND RIVER FLOW DATA

A comparison with average Lake Erie water levels was also made. The highest average yearly lake levels also occurred during the period from 1972 to 1976, as indicated below (taken from NOAA - Hydrograph of monthly mean levels of the Great Lakes).

| Year | Average Yearly Lake Level (IGLD-1955) |
|---|---|
| 1960 | 570.5 |
| 1961 | 570.6 |
| 1962 | 569.9 |
| 1963 | 569.4 |
| 1964 | 569.0 |
| 1965 | 569.0 |
| 1966 | 569.9 |
| 1967 | 570.4 |
| 1968 | 570.9 |
| 1969 | 571.5 |
| 1970 | 571.1 |
| 1971 | 571.3 |
| 1972 | 571.9 |
| 1973 | 572.7 |
| 1974 | 572.4 |
| 1975 | 572.2 |
| 1976 | 572.1 |
| 1977 | 571.2 |
| 1978 | 571.5 |
| 1979 | 571.6 |
| 1980 | 572.0 |

It is apparent that a general correlation between higher lake levels and higher intake turbidities exist, indicating that high lake levels probably cause nearshore lake water to be slightly more turbid. The simultaneous occurrence of high lake levels with high average yearly river flows for 1972-1975 makes a separation of the magnitude of each effect very difficult.

A breakdown of average monthly turbidities for the period 1970-1977 is shown in Table 1. As expected, turbidities are highest in the winter and spring months. The same pattern of high values during 1972-1975 and a subsequent return to normal levels is shown for each month. Analyzing Table 1, it appears there is a definite increase in turbidity and specific conductivity between 1972 and 1975. After 1975, the turbidity levels dropped to their pre-1972 values. The increase in both turbidity and specific conductivity levels clearly began before the construction of the breakwater in 1973 and subsequently decreased to pre-1972 levels in 1976 and 1977. Therefore, it is concluded that the breakwater was not the cause of the turbidity increase.

Average water temperatures for January, February, and March for the period 1968 to 1976 are given in Table 2.

Table 1 - Average Monthly Turbilities at Vermilion Water Intake (1)

| Month | Average Turbility (JTU) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
| January | 10 | 41 | 60 | 55 | 99 | 67 | 24 | 1 |
| February | 43 | 68 | 23 | 55 | 77 | 131 | 52 | 13 |
| March | 40 | 75 | 61 | 120 | 165 | 143 | 157 | 23 |
| April | 60 | 66 | 101 | 113 | 182 | 123 | 43 | 21 |
| May | 37 | 28 | 53 | 64 | 85 | 29 | 53 | 18 |
| June | 38 | 25 | 67 | 72 | 51 | 13 | 9 | 20 |
| July | 21 | * | 36 | 60 | 40 | 7 | 7 | 40 |
| August | 12 | 22 | 48 | 43 | 36 | 8 | 12 | 11 |
| September | 35 | 33 | 69 | 41 | 52 | 23 | 13 | 14 |
| October | 25 | 36 | 71 | 76 | 39 | 35 | 11 | 13 |
| November | 43 | 41 | 125 | 67 | 37 | 20 | 7 | 19 |
| December | 78 | 59 | 104 | 76 | 102 | 35 | 3 | 55 |
| Yearly Average | 36 | 45 | 68 | 70 | 80 | 53 | 24 | 21 |

* No data available.
(1) Source: Stanley Consultants, April 1978 based on information provided by the city of Vermilion.

Table 2 - Average Monthly Water Temperatures - °C (1) at the Water Intake

| Winter Of | December | January | February |
|---|---|---|---|
| 1968-1969 | 3.9 | 1.6 | 2.2 |
| 1969-1970 | 2.5 | 1.9 | 2.5 |
| 1970-1971 | 3.5 | 1.4 | 1.2 |
| 1971-1972 | 4.6 | 2.5 | 1.1 |
| 1972-1973 | 3.0 | 1.7 | 1.5 |
| | | - Breakwater Constructed - | |
| 1973-1974 | 4.1 | 2.0 | 1.8 |
| 1974-1975 | 2.7 | 1.8 | 1.9 |
| 1975-1976 | | - Insufficient Data - | |

(1) Stanley Consultants, April 1978 from data provided by the city of Vermilion.

As can be seen, the temperatures vary from year to year and follow no long-term trend either before or after the construction of the breakwater. In the case of Vermilion Harbor, it can therefore be assumed that temperature of the river water has no distinguishable effect on water quality.

The problems that have occurred with the Vermilion water supply have not been related to any trend, but rather are infrequent events when water of high solids content enters the intake and the necessary operational actions are not taken at the treatment plant to eliminate these solids from the supply. Considering all factors, data for several specific instances where high turbidity occurred were analyzed to see if short-term differences in water quality at the intake could be discerned between pre- and post-breakwater conditions. These data indicate that poor water quality at the water intake occurred both before and after breakwater construction. Such periods correlate well with high river flows, indicating that the Vermilion River is a significant source of the water quality problem at the water intake.

As stated earlier in this report, prior to construction of the breakwater in 1973, high river flows entering the lake would generally form a large plume off the harbor mouth. Open-lake currents would then deflect and transport the river water, but the area of primary influence would be expected to remain at least 500 to 1,000 feet offshore of the river mouth, except under heavy (15 mph) easterly or northerly winds. With the breakwater, however, the discharge plume is deflected east or west dependent upon wind direction and some of the water flows into the vicinity of the intake before it is incorporated into the lake currents. Therefore, it does appear that the breakwater does cause significant lowering of water quality at the water intake during high river flow periods under certain wind conditions. However, if appropriate operational actions are taken at the treatment plant to eliminate the pollutants, the quality of the water supplied to the city of Vermilion is acceptable for consumptive purposes.

## CONCLUSIONS ON THE EFFECT OF THE BREAKWATER ON WATER QUALITY AT THE INTAKE AND ON VERMILION WATER SUPPLY

Based on analysis of all available data, it is concluded that:

a. The breakwater has not had a significant impact on overall long-term water quality at the intake, as evidenced by the turbidity data.

b. Analysis of four specific short-term periods of poor water quality indicates that the Vermilion River is the cause of these occurrences, but conclusive evidence regarding the impact of the breakwaters is not available.

c. The breakwater has altered the patterns of dispersion of river water into Lake Erie. Under certain wind, flow, and/or ice conditions, the concentration of river water reaching the intake is increased, while under other conditions, river water influence on the intake is reduced. Conclusive data substantiating the relative frequency or intensity of these situations is not available.

d. The overall adverse impacts of the breakwater on the quality of the water supplied to Vermilion are not considered to be critical for the following reasons:

(1) The adverse effects on intake water quality occur only occasionally, and the breakwater's degree of responsibility is not conclusively known.

(2) The water has always been safe to drink. The Federal drinking water standards are consistently met.

(3) Efficient water treatment plant operation can effectively remove the impurities (mostly silt).

e. The location of the intake is such that it is susceptible to fluctuations in water quality that may affect color, taste, and odor, with or without the breakwater.

Therefore, it is concluded that mitigation of the impact of the breakwater on the municipal water supply is unnecessary.

RECOMMENDATION

Based on the conclusions reached, it is recommended that no further study of the impact of the breakwater on the municipal water supply be made.

# SWIMMING AREAS AND BEACHES

## INTRODUCTION

Pollution at Vermilion beaches has been a public concern for many years due to periodic closings and warnings. Since late 1973, when the breakwater was completed, some Vermilion residents have expressed the opinion that water quality at recreational swimming areas has been degraded by the deflection of river water toward Vermilion City Beach, Lagoons Beach, and Linwood Beach. The location of these beaches relative to the Federal project is shown on Figure 7.

The purpose of this section is to present the results of the Corps study to determine if the detached breakwater has had a significant impact on the quality in these swimming areas.

## WATER QUALITY AT VERMILION BEACHES

### Factors Affecting Water Quality

As stated before, water quality in Vermilion Harbor is dependent upon several factors: the quality of Lake Erie water, the quality of Vermilion River water, and the transport and mixing phenomena of the nearshore currents.

An assortment of pollution sources exists in the Vermilion River watershed, leading to poor quality in the Vermilion River. The most significant source of pollution in the river is agricultural runoff from upstream lands.

Previous analysis of current patterns has shown that the breakwater effect is the greatest for moderate winds from the west through southwest quadrant with deflection of the river plume to the eastern beaches.

### Water Quality Data and Standards

Water quality data has been collected at Vermilion and Lagoons Beaches by the Erie County Department of Health on an average of once a week. Of the data collected, the most important and regularly measured parameter is fecal coliform. Coliform organisms are harmless bacteria which are indicators of bacteria and other viruses that may be harmful to humans. Besides these data, Stanley Consultants collected samples at both the river and the beaches in the summer of 1977 for analysis of suspended solids, turbidity, fecal coliforms, and conductivity.

The State of Ohio water quality standards for contact recreation (EP-1, 1975) require that mean fecal coliform content shall not exceed 200 per 100 ml. In addition, not more than 10 percent of the samples shall exceed 400 per 100 ml. The standards are stated in greater detail in the section of this report titled, "Municipal Water Quality." If any three

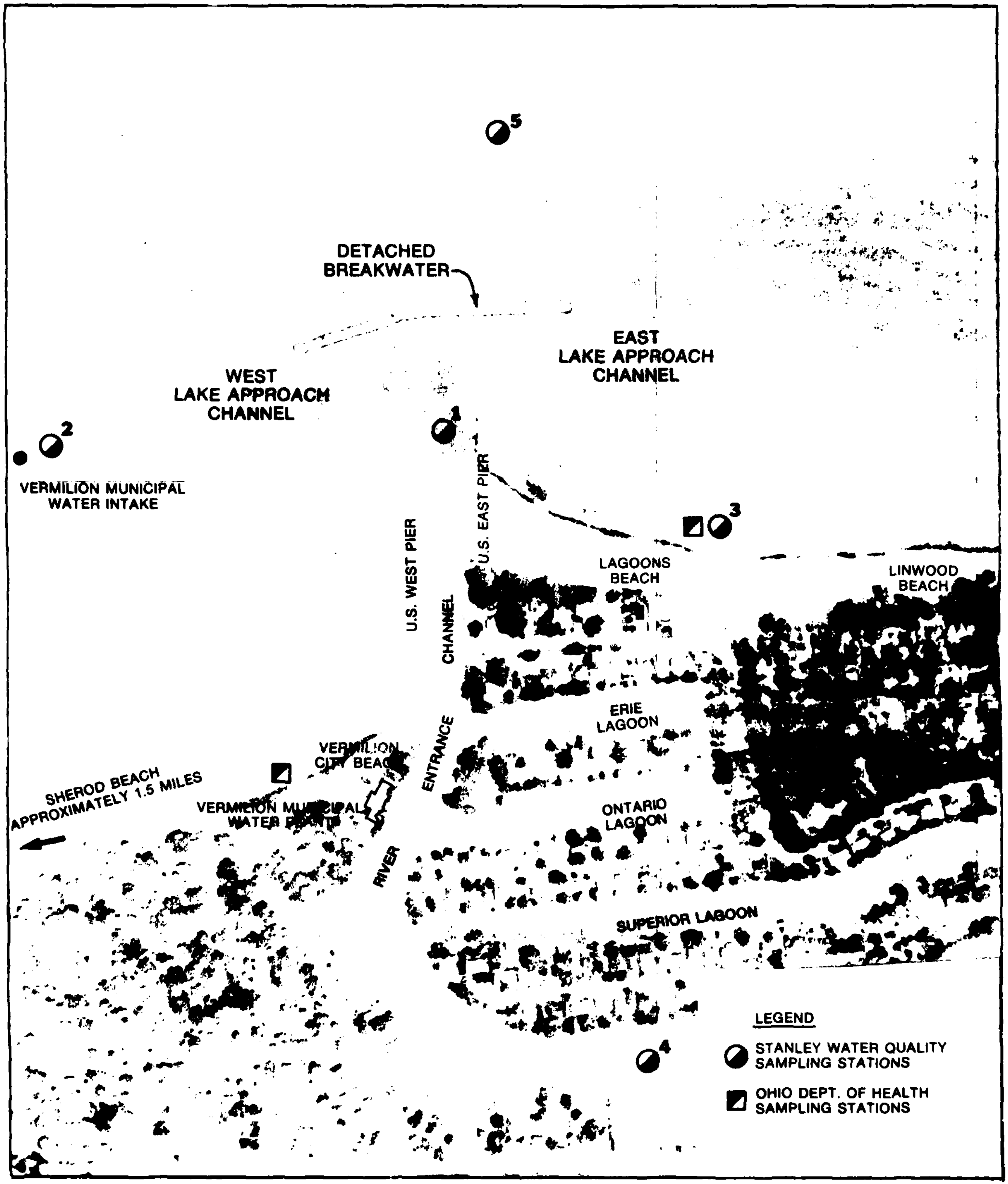



**Figure 7 • LOCATION OF VERMILION AREA BEACHES AND SAMPLING STATIONS**

successive weekly samples taken by the Erie County Department of Health exceed the 200 colonies per 100 ml, the beach is posted as unsafe.

Pollution Trends and Analysis

Fecal coliform data collected between 1971 and 1977 for Vermilion City Beach and Lagoons Beach are summarized in Tables 3 and 4. The locations of the sampling sites are shown on Figure 7. The Erie County Health Department has indicated that 200 colonies per 100 ml is the State standard for contact recreation. The beaches are posted as unsafe if three successive weekly samples show greater than 200 colonies per 100 ml. Figure 8 shows the percent of the water samples in which fecal coliforms have been in excess of this amount for each year of data. The graph shows that relatively clean water was enjoyed in 1975 and 1976, particularly at Lagoons Beach, and that a higher incidence of polluted conditions occurred in 1977. As can be seen from these tables and Figure 8, there is no discernible trend in the coliform count during the summer months, either before or after the breakwater was constructed.

Fecal coliform data for the river is of particular interest since correlation with beach data would be helpful in evaluating causes of beach problems. Unfortunately, the data cited above indicates that fecal coliform in the river is highly variable with no discernible historical summer trend. The data indicates that coliforms are high (from 200 to several thousand) in the river during the summer months. No correlation with high beach values is therefore possible. The conclusion is that river water is generally a potential pollutant to swimming areas and is likely to have adverse effects whenever it is transported to the vicinity without significant dilution.

Tables 5 and 6 below list the violations (coliform count greater than 200 colonies per 100 ml) that have been recorded for Vermilion City Beach (1971 through 1977) and Lagoons Beach (1973 through 1977). As can be seen from Tables 5 and 6, violations of the standard have occurred on a number of occasions, both before and after construction of the breakwater in 1973. These data also indicate that the violations are much more numerous to the west at Vermilion City Beach than to the east at Lagoons Beach. Also, periods of water quality degradation occurred during a wide range of Vermilion River flows, revealing no high correlation between river flow and poor water quality at the beaches although the swimming areas to the east may be more adversely affected for high river flows than during low flow periods since less dilution will occur during high flow periods. An example supporting this thesis is the high flow period in early July 1977 which preceded a 2-week period of poor water quality. For periods both before and after the breakwater, over 70 percent of the violations at both locations occurred when the winds were from the south to west. During those times, the amount of turbidity and floating debris also increased, possibly from resuspension of bottom sediments.

Table 3 - Summary of Fecal Coliform Data (2)
City Beach

| Year | No. Samples | Maximum (No./100 ml) | Mean (No./100 ml) | Std. Dev. | No. greater than 200 |
|---|---|---|---|---|---|
| 1971 | 18 | 624 | 84 | 142 | 1 |
| 1972 | 26 | 1,800 | 261 | 401 | 8 |
| 1973 | 41 | 1,560 | 179 | 284 | 10 |
| 1974 | 21 | 660 | 200 | 205 | 11 |
| 1975 | 26 | >1,000 | 180 (1) | 255 | 7 |
| 1976 | 21 | 566 | 96 | 128 | 3 |
| 1977 | 10 | 2,600 | 479 | 919 | 2 |

(1) Too numerous to count values.
(2) Stanley Consultants, April 1978.

Table 4 - Summary of Fecal Coliform Data (1)
Lagoons Beach

| Year | No. Samples | Maximum (No./100 ml) | Mean (No./100 ml) | Std. Dev. | No. greater than 200 |
|---|---|---|---|---|---|
| 1973 | 11 | 520 | 146 | 160 | 4 |
| 1974 | 7 | 560 | 131 | 196 | 1 |
| 1975 | 13 | 160 | 48 | 52 | 0 |
| 1976 | 12 | 730 | 91 | 202 | 1 |
| 1977 | 20 | 2,400 | 341 | 725 | 5 |

(1) Stanley Consultants, April 1978.

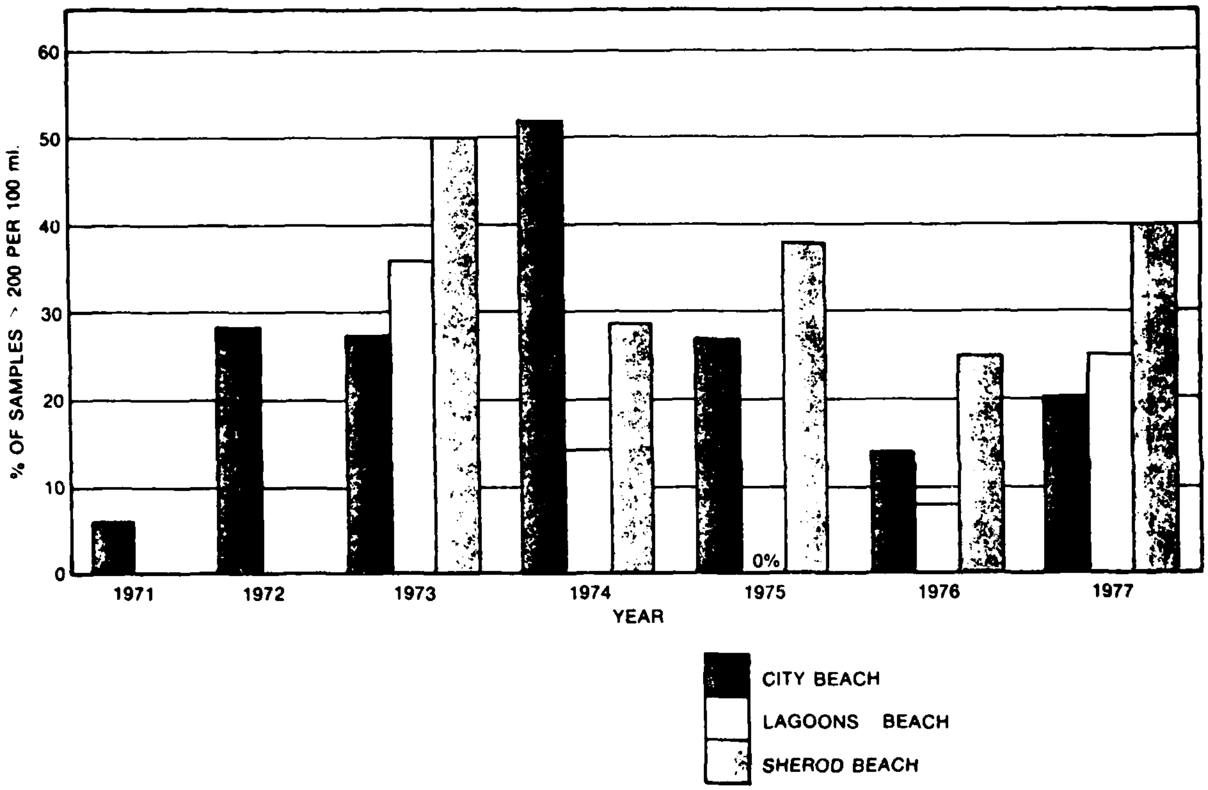



**Figure 8 HISTORICAL TREND OF HIGH COLIFORM COUNTS**

Table 5 - Summary of Coliform Violations Between 1971 and 1977 (1)
Vermilion City Beach

| Date | Fecal Coliform | Wind Direction | Wind Speed (mph) | Average Daily River Discharge (cfs) |
|---|---|---|---|---|
| 30 June 71 | 624 | 200° | 5 | 12 |
| 17 May 72 | 210 | 10° | 7 | 488 |
| 1 Jun 72 | 270 | 230° | 10 | 65 |
| 12 Jun 72 | 430 | 220° | 10 | 21 |
| 24 Jul 72 | 360 | 250° | 13 | 57 |
| 21 Aug 72 | 615 | 240° | 10 | 100 |
| 28 Aug 72 | 1,120 | 220° | 5 | 68 |
| 18 Sep 72 | 1,800 | 180° | 11 | 1,350 |
| 13 May 73 | 370 | 310° | 6 | 300 |
| 20 May 73 | 360 | 40° | 10 | 193 |
| 23 May 73 | 336 | 360° | 9 | 548 |
| 3 Jun 73 | 300 | 160° | 8 | 143 |
| 17 Jun 73 | 1,560 | calm | -- | 1,810 |
| 20 Jun 73 | 250 | 240° | 12 | 382 |
| 27 Jun 73 | 250 | 190° | 12 | 101 |
| 27 Jun 73 | 440 | 190° | 12 | 101 |
| 6 Jul 73 | 920 | 230° | 6 | 267 |
| 8 Jul 73 | 265 | 230° | 12 | 81 |
| 11 Jul 73 | 300 | 40° | 15 | 202 |

Table 5 - Summary of Coliform Violations Between 1971 and 1977 (1)
Vermilion City Beach (Cont'd)

| Date | Fecal Coliform | Wind Direction | Wind Speed (mph) | Average Daily River Discharge (cfs) |
|---|---|---|---|---|
| BREAKWATER CONSTRUCTION COMPLETED | | | | |
| 13 May 74 | 340 | 300° | 10 | 1,240 |
| 3 Jun 74 | 220 | 270° | 8 | 127 |
| 17 Jun 74 | <600 | 170° | 10 | 42 |
| 24 Jun 74 | 210 | 360° | 10 | 120 |
| 1 Jul 74 | 560 | 310° | 10 | 409 |
| 30 Jul 74 | 220 | 260° | 12 | 6.6 |
| 2 Aug 74 | 250 | 180° | 12 | 4.6 |
| 5 Aug 74 | 360 | 300° | 9 | 8.7 |
| 11 Aug 74 | 230 | 170° | 14 | 86 |
| 19 Aug 74 | 220 | 220° | 6 | 60 |
| 19 Aug 74 | 660 | 220° | 6 | 60 |
| 2 Jun 75 | 240 | 330° | 6 | 85 |
| 16 Jun 75 | TNTC | 250° | 10 | 198 |
| 16 Jun 75 | 280 | 250° | 10 | 198 |
| 21 Jul 75 | TNTC | 300° | 10 | 20 |
| 18 Aug 75 | 220 | 330° | 9 | 14 |
| 25 Aug 75 | 226 | 220° | 11 | 20 |
| 26 Aug 75 | 250 | 310° | 8 | 49 |
| 28 Jun 76 | 260 | 340° | 8 | 27 |
| 6 Jul 77 | 2,600 | 260° | 14 | 2,060 |
| 13 Jul 77 | 1,767 | 270° | 13 | 76 |

TNTC - Too numerous to count.
(1) Stanley Consultants, April 1978.

Table 6 - Summary of Coliform Violations Between 1973 and 1977 (1)
Lagoons Beach

| Date | Fecal Coliform | Wind Direction | Wind Speed (mph) | Average Daily River Discharge (cfs) |
|---|---|---|---|---|
| 6 Jul 73 | 520 | 230° | 6 | 267 |
| 12 Jul 73 | 236 | 240° | 8 | 171 |
| 24 Jul 73 | 220 | 160° | 6 | 130 |
| 2 Aug 73 | 310 | 270° | 6 | 21 |
| BREAKWATER CONSTRUCTION COMPLETED | | | | |
| 22 Jul 74 | 560 | calm | -- | 6.9 |
| 21 Jun 76 | 730 | calm | -- | 15 |
| 26 May 77 | 500 | 60° | 15 | 20 |
| 6 Jul 77 | 2,400 | 260° | 14 | 2,060 |
| 13 Jul 77 | 631 | 270° | 13 | 76 |
| 19 Jul 77 | 350 | 220° | 6-10 | 84 |
| 8 Sep 77 | 2,400 | 30° | 12 | 810 |

(1) Stanley Consultants, April 1978.

## CONCLUSIONS REACHED BY STANLEY CONSULTANTS

Based on the results of its investigation, Stanley Consultants reached the following conclusions regarding the effect of the detached breakwater on adjacent beaches:

a. The breakwater has no significant effect on Vermilion City Beach.

b. The breakwater diverts river water to Lagoons Beach and Linwood Beach during south and west wind conditions. This results in an adverse impact on these beach areas. Based on available water quality data, this effect does not appear to have significantly changed water quality from a public health standpoint (bacteria). However, the movement of turbid river water and floating debris along the beaches has been cited by the public and observed during the study. These conditions are detrimental to the use of the beaches and have resulted in violation of State water quality standards at the recreational swimming areas.

c. The Lagoons and Linwood swimming areas are not significantly affected by the breakwater during other wind conditions.

On this basis, Stanley Consultants ". . . recommended that mitigation measures to reduce pollution of the Lagoons and Linwood recreational swimming areas be considered."

## BUFFALO DISTRICT'S REVIEW AND SUBSEQUENT ACTIONS

In reviewing and evaluating Stanley Consultants recommendation to reduce pollution on the eastern beaches (Lagoons and Linwood), the Buffalo District concluded that further study to quantify the severity of the breakwater impact was required prior to reaching a conclusion on the need for mitigation. Therefore, Stanley's contract was modified to include a discussion of available methods to quantify the breakwater innpact and an evaluation of the reliability of these methods. A summary discussion of this work by Stanley Consultants follows.

Both physical and mathematical modeling were considered as possible methods to quantify the breakwater effects. To obtain data for existing conditions, an extensive sampling program would be required. The data from this sampling program would be needed to calibrate and verify both the physical and mathematical models. Stanley Consultants, however, concluded that serious limitations preclude using a physical model, and that simplifying assumptions required in math modeling could limit the accuracy of results. Because of these limitations and the subjectiveness of any decision on mitigating the breakwater impact, Stanley concluded that the decision should be based on the results of the previous study and an analysis of costs, benefits, and other impacts that would mitigate beach pollution.

The Buffalo District agreed with this evaluation of the need for and reliability of modeling studies and concluded that the basis for mitigation should be based on tangible quantifiable recreational damages caused by the breakwater. The yardstick selected was the number of times that the eastern

beaches had been posted as unsafe since the breakwater construction in 1973. An assumption would be made that all such postings since 1973 were caused by the breakwater, and recreational damages would be based on projected utilization loss for these periods.

From 1970 to 1980, the State of Ohio and the Erie County Department of Health collected fecal coliform data at beaches in the Vermilion area. Table 7 provides a summary of the available data for the three beaches in question. An analysis of the data reveals that Vermilion City Beach has been posted six times, all post-breakwater. Neither Linwood nor Lagoons Beach have been posted during the period of record.

Although pollution problems at Vermilion City Beach appear to stem from sources other than the Vermilion River, the same cannot be said for the Lagoons and Linwood Beaches. Under certain wind conditions, particularly westerly and southwesterly winds, dirtier Vermilion River water is diverted by the breakwater to these beaches. Although this appears to happen more under post-breakwater conditions, it has not resulted in enough of a water quality problem at the beaches to have them posted as "unsafe" by the Erie County Department of Health.

DISTRICT'S CONCLUSION ON MITIGATION OF BEACH POLLUTION

The Buffalo District concludes that although the breakwater does deflect the river discharge to Lagoons and Linwood Beaches for west to south wind conditions, as well as increasing turbidity and debris, there does not appear to be a significant change in the water quality from a public health standpoint. No instances of "unsafe" postings for public health or turbidity and floating debris have been recorded since construction of the breakwater, so there has been no quantifiable recreational damages caused by the breakwater. Therefore, the District concluded that mitigation of the impact of the breakwater on beach pollution is not required, and should not be considered further.

Table 7 - Summary of Coliform Data and Postings for Vermilion Beaches, 1970-1980 (1)

| Year | Vermilion City Beach | | | Linwood Beach | | | Lagoons Beach | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of (2) Samples | No. over (3) 200 coliform Per 100 ml | No. of (4) Postings | No. of (2) Samples | No. over (3) 200 coliform Per 200 ml | No. of (4) Postings | No. of (2) Samples | No. over (3) 200 coliform Per 200 ml | No. of (4) Postings |
| 1980 | 12 | 6 | 4 | 12 | 3 | 0 | 12 | 5 | 0 |
| 1979 | 7 | 1 | 0 | 7 | 1 | 0 | 7 | 1 | 0 |
| 1978 | 11 | 6 | 1 | 10 | 3 | 0 | 11 | 4 | 0 |
| 1977 | 14 | 3 | 0 | | Not tested | | 14 | 4 | 0 |
| 1976 | 12 | 2 | 0 | | Not tested | | 12 | 1 | 0 |
| 1975 | 13 | 3 | 0 | | Not tested | | 13 | 0 | 0 |
| 1974 | 7 | 4 | 1 | | Not tested | | 7 | 1 | 0 |
| BREAKWATER CONSTRUCTED | | | | | | | | | |
| 1973 | 12 | 3 | 0 | | Not tested | | 11 | 4 | 0 |
| 1972 | 25 | 10 | 0 | | Not tested | | | Not tested | |
| 1971 | 18 | 1 | 0 | | Not tested | | | Not tested | |
| 1970 | 33 | 7 | 0 | | Not tested | | | Not tested | |
| Totals: | 164 | 46 | 6 | 29 | 7 | 0 | 87 | 20 | 0 |

(1) Source: Erie County Health Department.
(2) Includes all samples taken at that beach in any particular year including replicate samples on any given day.
(3) Includes all samples where counts of coliform exceeded 200 per 100 ml.
(4) Beach is posted as "unsafe" when any three consecutive weekly samples exceed 200 coliform per 100 ml.

# ICE JAM FLOODING

## INTRODUCTION

The formation and behavior of ice is of great significance in small-boat harbors throughout the Great Lakes. In the Vermilion River, the severest problem associated with ice is the potential for ice jams and subsequent flooding. The impact of the detached breakwater at Vermilion harbor on ice formation and jamming in the river and lake channels was evaluated by Stanley Consultants in 1977 and 1978. Stanley Consultants concluded (April 1978 report) that, with the breakwater, the probability for ice jams has been reduced because windrowing no longer occurs at the pier ends as it did before breakwater construction. However, Stanley did note that under certain conditions, icebreaking operations by the Coast Guard might not be possible with the breakwater. Therefore, Stanley recommended that additional consideration be given to mitigation of navigation problems related to icebreaking operations by the Coast Guard's Cutter KAW which is a 110-foot vessel. As a result, the Buffalo District awarded a contract to Tetra Tech Inc. in the summer of 1979 to evaluate certain modifications for improving access of the Coast Guard's 110-foot cutters to Vermilion Harbor for icebreaking operations. Appendix B, is Tetra Tech's July 1980 report on the study of possible harbor modifications for icebreaking purposes.

This section melds these two reports into a comprehensive summary of the ice jam problem and the conclusions reached by Buffalo District regarding the need for mitigation.

## ICE PHENOMENA

### Ice Formation

The behavior of ice in a river-lake interface situation depends upon the complex interaction of many physical factors. For this reason, ice conditions around Vermilion often differ significantly from year to year, and even during any given winter. During initial ice formation, the following are significant:

- Air and water temperature.
- River currents and rainfall.
- Wind and resulting lake currents.

Formation of ice is a direct result of low air temperature lowering the water temperature of the lake and river. The cooling process in a slowly moving river or lake may be divided into two phases. First, low temperatures and strong winds combine to cool the surface water, causing it to sink. Vertical mixing is thereby induced, and the entire water body must be cooled until it reaches 39°, the temperature of maximum density. Once this uniform temperature exists, conditions are conducive to formation of ice. The exact

time or conditions for ice formation depends on many factors other than temperature, including wind, waves, water currents, water depth, and shoreline configuration.

In Phase 2, surface water is further cooled below 39°, but remains lighter than the water below. Wind and water currents create vertical motion, and bring up heat from the depths where the water is still close to 39°. This retards the freezing process. For this reason, cold calm weather is more favorable to ice formation than windy conditions or times of high river discharge.

a. Lake Ice Formation

The nearshore lake at Vermilion freezes when temperature and other climatological conditions permit the above cooling process to occur. The top layer of water eventually drops well below the freezing point, and ice plates form. The situation is further complicated, however, by the influence of the Vermilion River, particularly in the area around the breakwater. River flows hinder ice formation in the vicinity of the river mouth, and can break up newly formed sheets. Waves on Lake Erie also cause new ice to break up and refreeze.

During an average winter, the nearshore lake is ice covered for three to five weeks although a side variation from "normal" may exist for any given year. For nearshore Lake Erie in the vicinity of Vermilion, Figure 9 shows the probability range that ice cover will exist. The upper and lower limits of the curve are based on the range of probability that ice cover exists on any given day. From Figure 9 it is seen that there is a high probability (75 percent to 98 percent chance) that ice cover will exist in February of any given year.

b. River Ice Formation

In the Vermilion River, ice formation is dependent upon two distinct processes. The first involves the phenomena of frazil ice production, while the second might be termed shore ice growth.

Frazil ice crystals form in supercooled (below freezing) turbulent waterways, and have the appearance of small circular plates, ice pans, slush, or porous flocs (Figure 10). Initially, nucleation of the crystal occurs around either a small foreign particle or by a chance orientation of water particles to form the crystalline structures of ice. In contrast to the freezing of droplets and quiet water, which occurs at temperatures many degrees below freezing, frazil crystals form in water only slightly under 32°F. Frazil ice grows quickly due to the rapid production rate and a continuous splitting of growing ice flocs. Eventually, the frazil particles evolve into ice flows, freeze together, and create the ice cover on a river. The ice cover insulates the river, and retards further frazil formation.

Shore ice is the first type of ice to appear in laminar flow areas near the shore of a river. Ice is nucleated at the bank, which is colder than the water, and then grows toward the middle (Figure 10, Photo d). During the

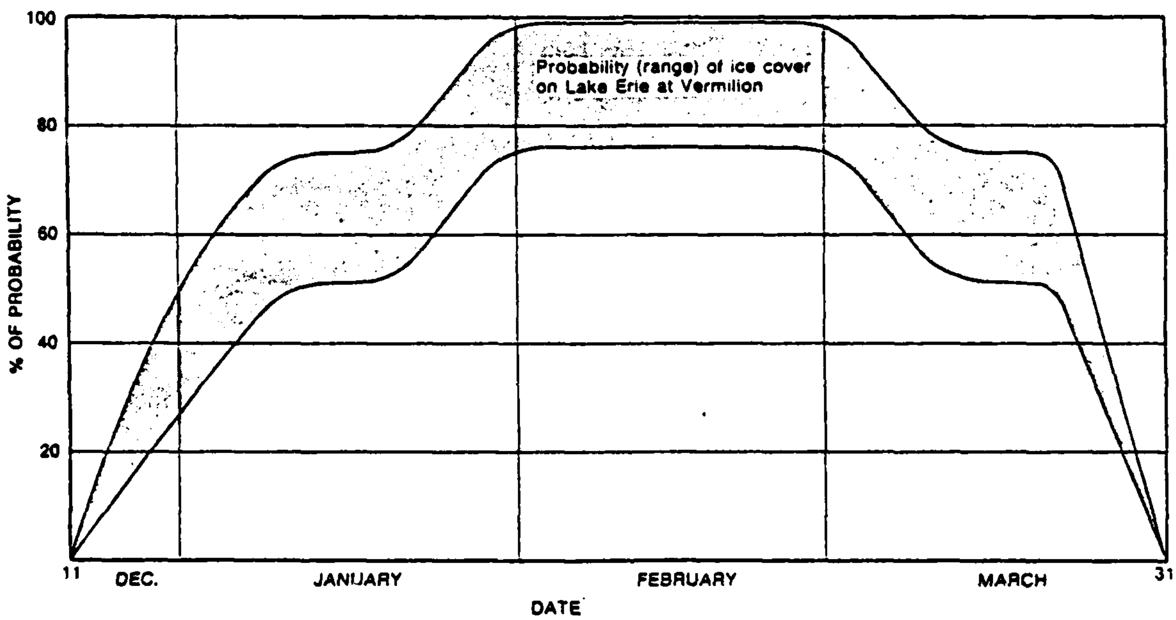
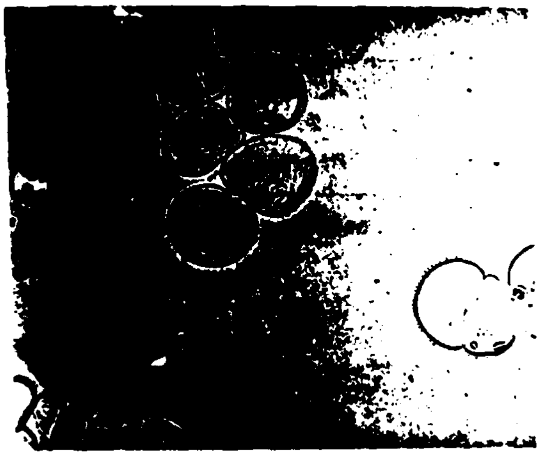
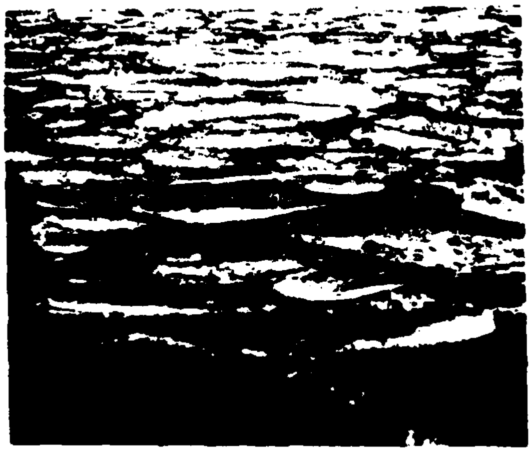



**Figure 9 • PROBABILITY OF ICE COVER**



a. Frazil

b. Frazil slush



c. Plate ice

d. Shore ice

e. Slush balls

f. Pancake ice

**Figure 10 • FORMS OF ICE**

growth process, frazil flocs in the river can become attached to the shore ice, accelerating the development of an ice cover. Because the shore ice process is slow compared to frazil evolution, it takes a long time to cover large or rapidly flowing rivers. Shore ice growth is dominant, however, in small rivers and brooks.

The Vermilion River freeze-up may be dominated by either shore ice growth or frazil production, depending on the relationship between river flow and water temperature. Low flow during very cold periods is conducive to shore ice growth, whereas significant river flow enhances frazil production, even if water temperature is higher.

In the harbor mouth area, between the breakwater and pier ends, sheet ice may form as in a relatively quiet lake, or the frazil and shore ice processes typical in rivers may dominate. The critical factor again is water velocity and associated turbulence. Unfortunately, the complex interaction of lake currents and very unsteady, pulsing river flow (due to lake level variations) make analytical evaluation of the turbulence difficult. In addition, the relationships between flow velocity and ice formation and growth are not completely understood, and accurate prediction of ice conditions at the harbor mouth is not possible.

Conditions in a normal Vermilion winter include fairly continuous cold temperatures, limited snow, and low river flow. An analysis of data for the Vermilion River indicates that velocities in the river are less than 0.3 feet per second 95 percent of the time. Under these low velocity conditions, shore ice grows from the banks and other appurtenances, while frazil ice or sheet ice may form in mid-channel, eventually forming a solid ice cover in the river. "Shore" ice also develops at the pier ends and at the breakwater. The area between piers and breakwater generally freezes solid as sheet ice.

## Ice Growth, Transport, and Distribution

The formation of an ice cover is only the first step in the development of ice conditions in a harbor. Wind, lake currents and waves, and river flow combine with water temperature to determine the specific ice situation.

During the growth process, hydraulic forces fracture weaker ice areas and transport the resulting ice blocks or sheets, which in turn can refreeze in other locations depending upon prevailing temperatures. Hydraulic forces of significance include water forces (currents), wave forces, and wind forces.

Water and wave forces may break up fast ice, primarily through vertical lifting; and the drift ice (blocks or floes) is then transported until an obstruction or other ice barrier is met. Ice blocks impinging on fast ice in this manner may be submerged under or pile on top of the stable ice, thus adding to the thickness.

Wind plays a very significant role in moving ice broken by water forces. Of particular significance to this study is the piling up of drifting masses of lake ice pushed against the shore or against fast ice by the wind. The resulting "windrows" consist of a jumbled mass of ice blocks and sheets, and

will continue to grow as long as the wind persists. Photograph 9, on page 50, shows windrowed ice lakeward of the breakwater on 30 January 1978. Windrows normally form in water 4 to 8 feet deep and are reported to have reached 10 to 15 feet or higher near the mouth of the harbor both before and after construction of the breakwater. Once the wind dies, the ice blocks are forced downward by gravity and spread out. Windrows will therefore decay unless they are tightly packed or have been cemented in place by refreezing.

The locations of these windrows have a significant effect on spring ice flow out of the river and on icebreaking operations. The offshore breakwater at Vermilion has eliminated windrows at the harbor mouth, but windrows can now form in the lake approach channels.

Generally, the river and channel area becomes solidly frozen sometime in early January. From this time on, the primary movement of ice is in the lake, where continuous breaking up and transporting of blocks with the winds and currents takes place. Photograph 10, taken 25 January 1962, long before breakwater construction, shows fast ice in the river, an open area in the harbor entrance channel, and the piling up of ice floes along the shore at a water depth of about 6 to 8 feet. During most winters, the entire nearshore

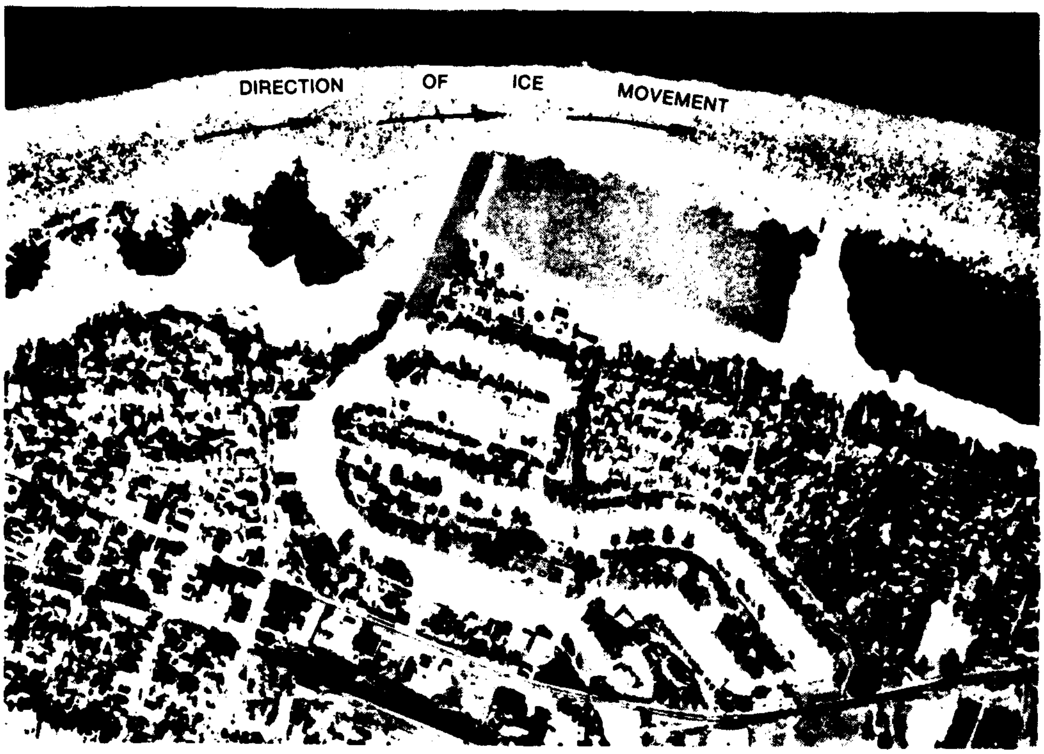
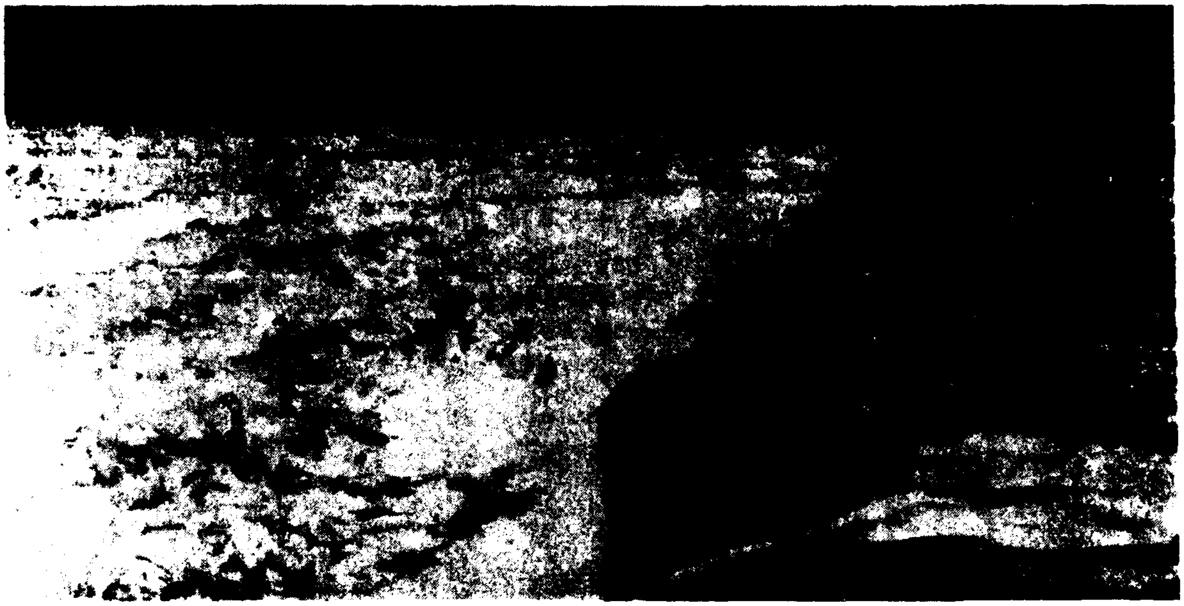
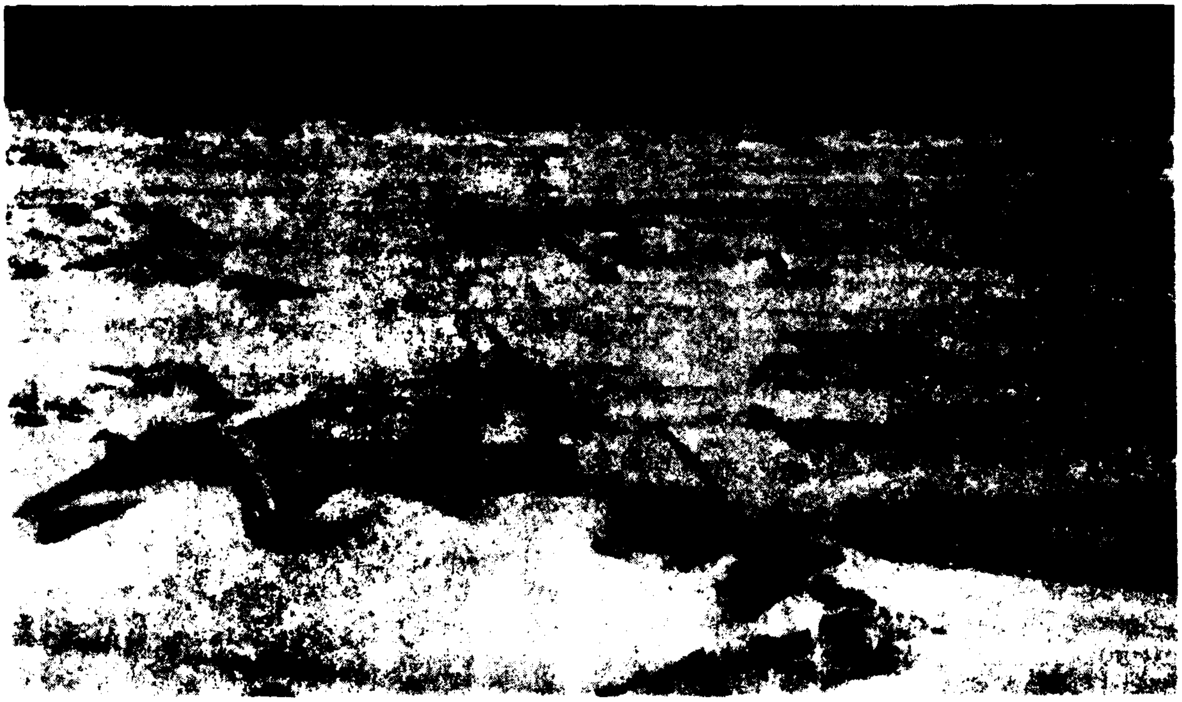



Photo 10 • PHOTOGRAPH SHOWING ICE MOVEMENT AT VERMILION (Jan. 25, 1962)



WINDROW ICE ON NORTH FACE OF THE BREAKWATER (Jan. 30, 1978)



DETAIL OF WINDROW ICE (Jan. 30, 1978)

Photo 9 · WINDROW ICE AT VERMILION BREAKWATER

lake area becomes frozen, and windrows may form significant "walls" near the harbor mouth. This situation exists until a prolonged period of high temperatures creates a thaw of the river. This usually occurs in mid to late February, although January thaws are not uncommon. When early thaws occur, an ice cover is often reestablished when colder temperatures return.

## Ice Breakup

The process of ice breakup is initiated by high temperatures and/or rainfall melting and weakening the ice. Ice is broken by the hydraulic force of the river into blocks and sheets, which flow with the river currents until they reach the open lake or get stuck on some obstacle. It is when these flow obstructions are encountered that the danger of ice jams arises. Ice frequently jams at the many obstacles, channel constrictions, and bends present in the Vermilion River. The duration of the jams is highly variable, depending on ice size and strength and river flow. Eventually, jams in the upstream areas break free and the ice rushes through the harbor area toward the lake. The most desirable situation, obviously, is when the ice flows unhindered out the harbor channel and into the open lake. However, this rarely occurs without considerable human effort.

When the river breaks up, the lake is normally still frozen near the shoreline. Windrows along the shore often do not completely thaw until late April. Ice flowing down the river therefore may form a jam where it meets the lake ice unless a path to open water is provided. Icebreakers have generally been employed to clear this path both prior to and since construction of the breakwater. Icebreaking operations at Vermilion have included a small City icebreaker, steel-hulled fishing boats, a 60-foot tug, and assistance by the U.S. Coast Guard's 110-foot Icebreaker "KAW." In addition, blasting has been used to hasten ice breakup.

## Ice Jams

Ice jams can form at various critical points along the river channel. The basic requirements for formation of an ice jam include:

- A large discharge of frazil or fragmented solid ice,
- An obstacle which impedes the downstream passage of the ice including:
  - Channel constrictions such as bends, abutments, piers, shoals, or flow regulating structures.
  - Ice frozen fast to the shore or river bottom (anchor ice).
  - Lake ice driven to a river mouth by wind, where it becomes grounded.
  - An abrupt decrease in stream slope, which reduces velocity.

In the winding Vermilion River, channel constrictions and the previously discussed lake ice barrier are particularly important. Figure 11 shows the

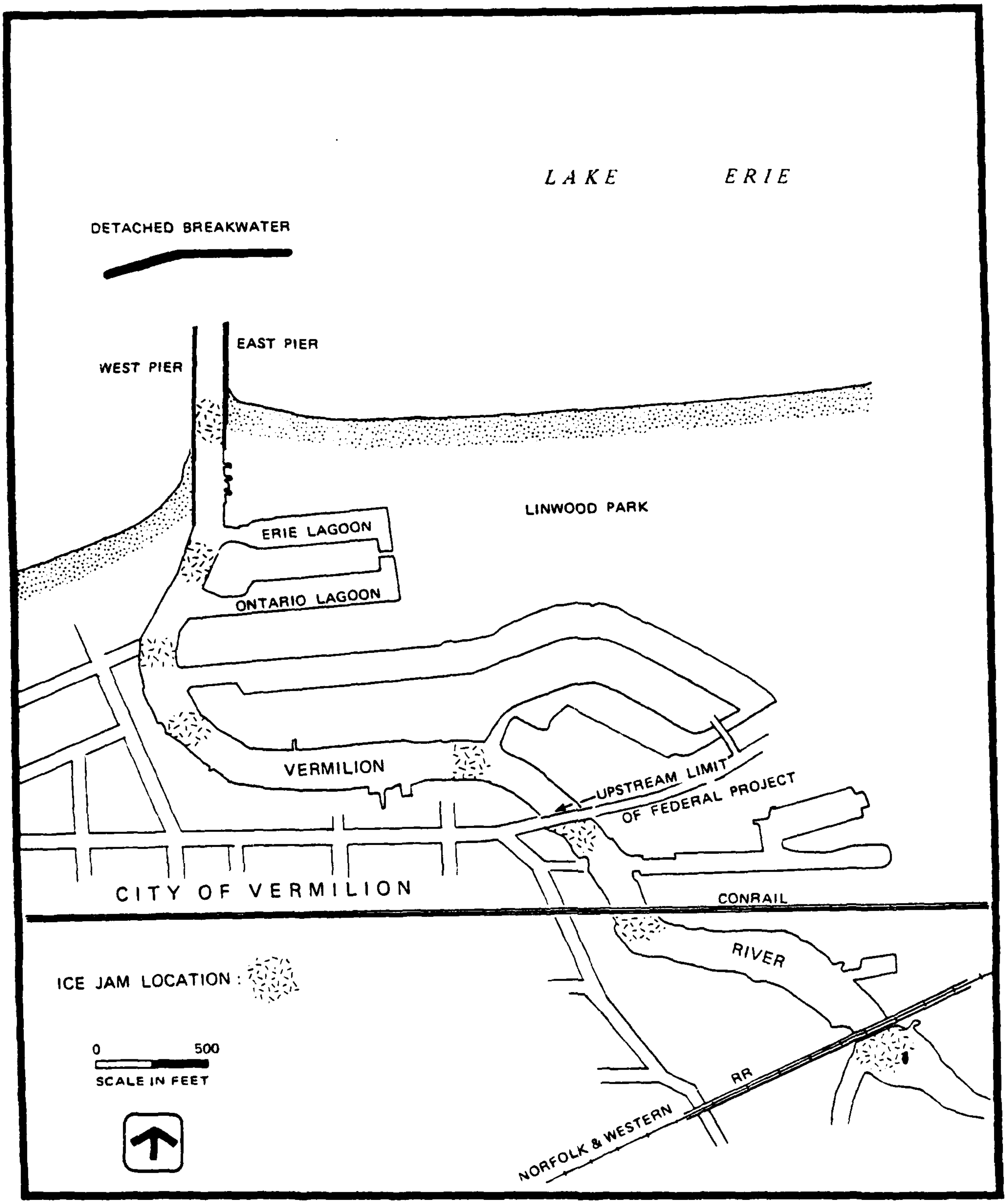



Figure II • HISTORICAL ICE JAM LOCATIONS, VERMILION HARBOR

location of such areas where significant ice jam potential exists. The formation and evolution of a typical jam can be divided into three phases:

- Jam initiation, when floating ice floes encounter an obstacle and form an ice "bridge" across the stream.

- Jam growth, both in length and thickness, when arriving flows are arrested at the upstream edge of the ice cover; a schematic representation of the growth of a jam is shown on Figure 12.

- Jam collapse by internal failure, due to exceeding of the compressive and shear strengths of the ice cover. Often icebreaking efforts are required to break the jam.

The length and thickness of an ice jam is determined by the supply of ice moving down the river and the velocity of the stream. As the jam thickens, the cross section area of the stream decreases, thus limiting the flow of water that can pass. The water level behind the jam then rises, and flooding may result.

a. <u>Types of Ice Jams</u>

There are essentially two types of ice jams (Figure 13). Simple jams are caused by regular accumulation of ice floes at a solid ice cover. The jam thickens, but water continues to flow under the accumulation. The water level rises slowly upstream because the jam has reduced the river flow capacity. These jams occur frequently, and may be destroyed by river discharge or the momentum of large floes. "Dry ice jams," however, may occur in irregular river beds or at a large obstacle. The jam completely blocks the flow section and water backs up rapidly, depending on the amount of flow, creating hazardous flood conditions. Photograph 11, following, shows a typical ice jam in the Vermilion River.

b. <u>Evaluation of Ice Jams</u>

The state of the art for evaluating and predicting ice jams is not well advanced. Dry ice jams depend upon a fortuitous orientation of ice blocks at an obstacle. Analytical research has been centered on predicting growth and strength of simple ice jams, but most investigations have relied upon significant simplifications that limit applicability to actual situations. Quantitative methods are not yet available to predict the occurrence or severity of jams.

Numerous observations have been made of jams, and the critical hydrologic and climatic factors are understood. It is therefore possible to determine in general terms what conditions are likely to result in jams and related flooding. The four relevant factors are:

- <u>Winter Ice Conditions</u> - Varieties of ice conditions are possible depending upon the water temperature and flow history of the river. Of particular importance is the variation in thickness of the ice cover. If the ice is of uniform thickness throughout the stream length, chances are better

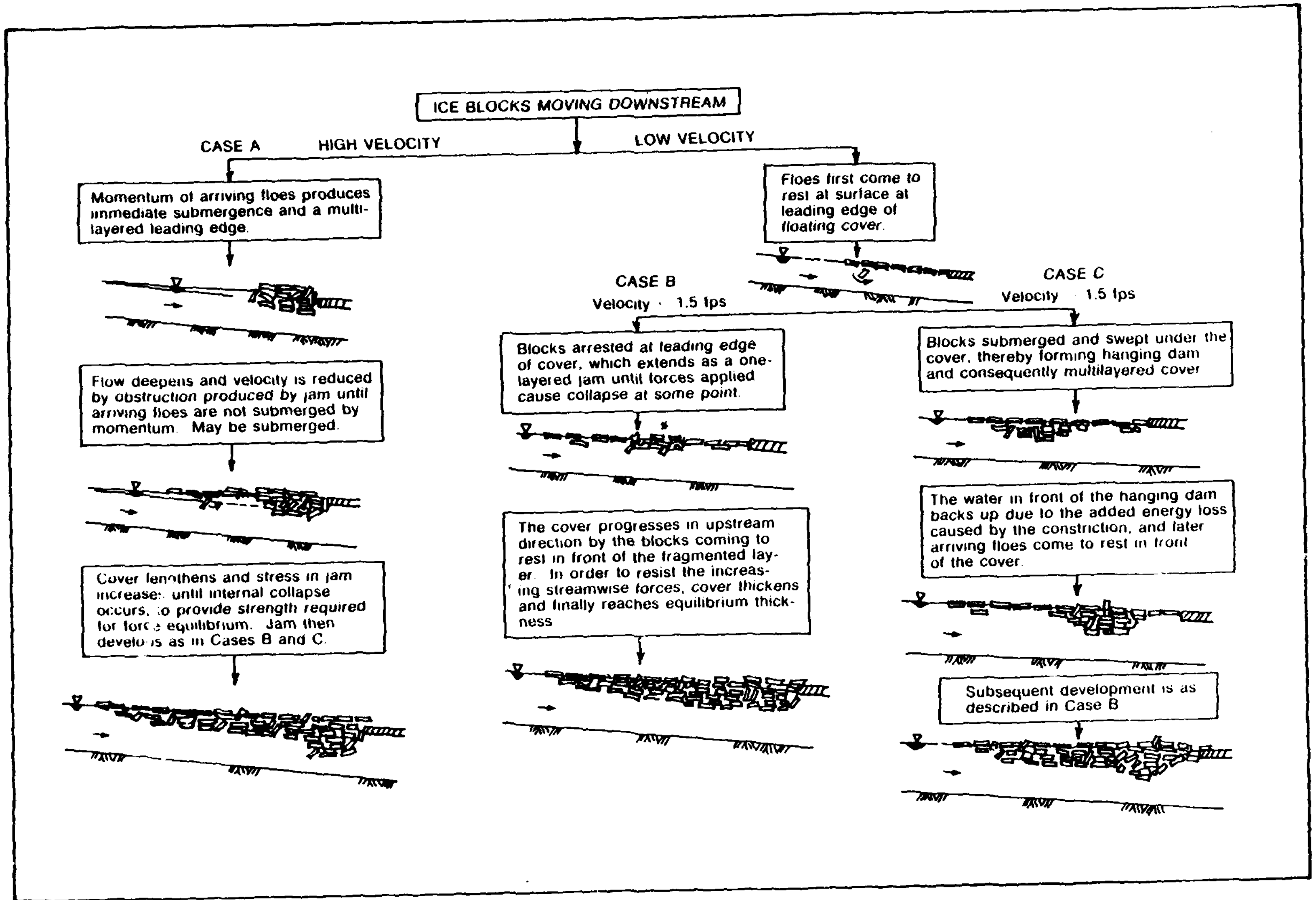



Figure I 2 • DEVELOPMENT OF ICE JAMS

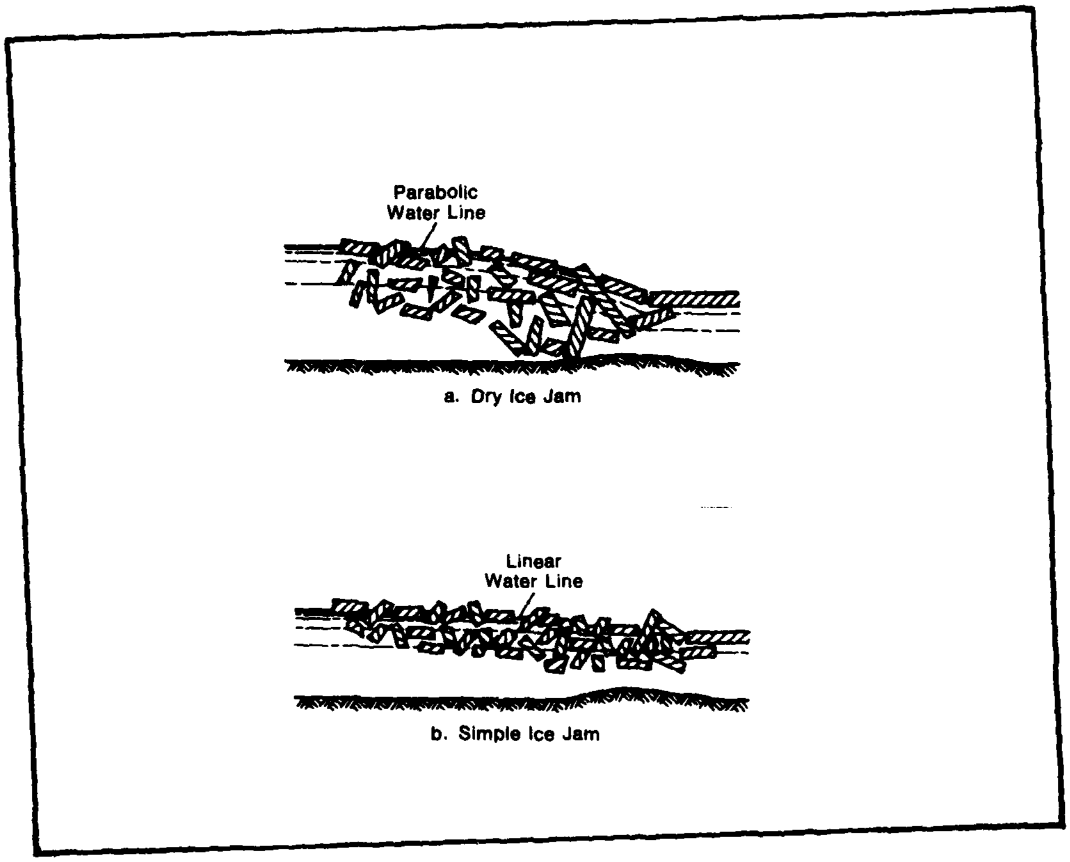



**Figure 13 • TYPES OF ICE JAMS**

Photo 11 • TYPICAL ICE JAM ON VERMILION HARBOR (March, 1963)

that it will break up uniformly. If however, certain areas are significantly thicker, these will still be strong when upstream breakup occurs and may catch the flow of ice as it moves downstream. Long, cold winters with limited snow cover create the thickest ice; early winter thaws may form partial jams which refreeze in place, creating areas of significantly thicker ice. These spots are then potential barriers and may cause severe ice jams during the main spring breakup. Ice formation may also occur in such a way that significant quantities of frazil ice are formed and deposited on the underside of the ice cover, which hinders passage of ice and water during breakup.

• Water Discharge at Breakup - An early large spring flood will cause the worst jams in a river because the ice is broken while it is relatively strong. Stronger ice blocks create larger, more stable jams. Rainfall on frozen ground results in more runoff, creating high river flows. These flows, along with the larger jams, may result in serious flooding. A late flood will move decayed ice more easily and the resulting jams will be weaker. A rapid melt will also increase river flow and improve the probability of jamming by creating a large influx of ice.

• Hydraulic Features - As mentioned previously, sharp bends, narrows, natural or man-made abutments, and shoals are prime areas conducive to ice jams.

• Wind and Currents - The wind and lake currents at the mouth of the harbor have an effect on windrow formation. Northerly winds create the most hazardous conditions by piling ice up at the mouth, whereas southerly winds

assist the ice in moving out of the harbor to the open lake. In the river itself, winds also play a role in the transport and distribution of ice blocks.

## EVALUATION OF BREAKWATER IMPACT ON ICE JAM FLOODING

As discussed previously, ice formation is primarily dependent upon water temperature, and influenced by the thermal and hydraulic effects of currents and waves. By design, the offshore breakwater has some impact on the waves and currents at the harbor mouth. Wave action is reduced in the shadow area between the breakwater and piers, and currents have been deflected by the structure.

In the river channel (area south of pier ends), ice formation proceeds as a function of water temperature and water motion. The effect of the breakwater on currents in the Vermilion River was analyzed through the use of a computer model (HEC-2). Separate analyses were conducted for several river flows and a high, average, and low lake level elevation. The maximum change in computed average river velocity occurred at the lowest lake level. The results are summarized in Table 8.

Table 8 - Maximum Breakwater Effect on River Velocity
Lake Erie Level = 568.0 (IGLD) (1)

| River Discharge | Average Velocity | Maximum Reduction in Velocity Due to Breakwater | |
|---|---|---|---|
| (cfs) | (fps) | (fps) | (%) |
| 500 | 0.34 | <0.001 | <0.1 |
| 1,000 | 0.68 | <0.001 | <0.1 |
| 3,000 | 2.04 | 0.004 | 0.2 |
| 14,000 | 9.52 | 0.078 | 0.8 |

(1) Stanley Consultants, April 1978.

The effect of the breakwater will decrease further at flows below 500 cfs. The flow of the Vermilion River averages about 240 cfs, and is less than 3,000 cfs 99 percent of the time.

It is concluded that the breakwater does not have a significant effect on currents in the Vermilion River. Therefore, the formation of ice in the river is the same as before breakwater construction. The only factor changed is the waves and surge present in the harbor. The reduction in waves and surge that the breakwater has provided could result in a slight reduction in the breakup and refreezing of the river ice. This would tend to make the ice cover more uniform. It must be remembered, however, that river currents and wind waves within the harbor still can cause breakup of newly formed ice sheets.

Ice borings in February 1977 to determine the ice thickness in the river and shoreward of the breakwater. The results are shown on Figure 14. The thickness is remarkably consistent at 1.5 to 2 feet throughout the channel area. Whether this uniformity is due in part to the reduction in waves and surge provided by the breakwater is impossible to ascertain, since no data prior to breakwater construction are available.

The only ways in which the breakwater can have a significant impact on the growth and transport of ice are:

- Alteration of the river and lake currents.

- Creation of an additional barrier at which ice may collect.

It has been shown that the breakwater has not significantly affected river currents. Waves and surge have been reduced, thus limiting new ice breakup and encouraging uniformity of the ice cover in the river. The thickness data supports this concept. The logical conclusion is that the breakwater has not had a significant effect on transport in the river channel since the critical factors (river currents and wind) have not been affected.

In the area between the breakwater and the ends of the piers the breakwater has reduced wave action thus reducing breakup and refreezing of ice sheets. This quieting of the water will enhance initial formation but will retard the thickening process. The current patterns in this area have become more irregular as turbulent eddies are created by the breakwater. The effect on ice formation of these instantaneous current variations is impossible to predict. However, the thickness data does indicate that no buildup of thicker ice occurs in the lake channel area. This area has sheet ice with only minor piling up on the south side of the breakwater. Photo 12, illustrates this condition. The conclusion that can be drawn is that the breakwater has not caused thicker ice formations in the area between the breakwater and the ends of the piers, and in fact has probably reduced the ice buildup in this area. This conclusion is substantiated by a comparison of Photo 9, taken on the same day.

Therefore, in the area around and between the breakwater and the pier ends, the structure has had significant effects on the distribution of ice. The breakwater now presents a physical obstruction to lake ice moving toward the south shore and to a lesser extent ice moving parallel to the shore. Prior to the breakwater, ice was free to move unhindered in the area offshore of the piers (Photograph 10). The distribution of ice packs and windrows formed by the moving ice depended upon the wind and current conditions. Northerly winds tended to pile up windrows at the pier ends and parallel to the shore, while southerly winds transported ice away from the harbor mouth. East or west winds pushed ice against the piers or the fast ice adjacent to the piers. With the breakwater in place, northerly winds pile up windrows at the breakwater (Photograph 9) and east and west winds drive packs against the fast ice in the lake approach channels inside the breakwater. Figure 15 shows the generalized patterns of ice before and after the breakwater construction.

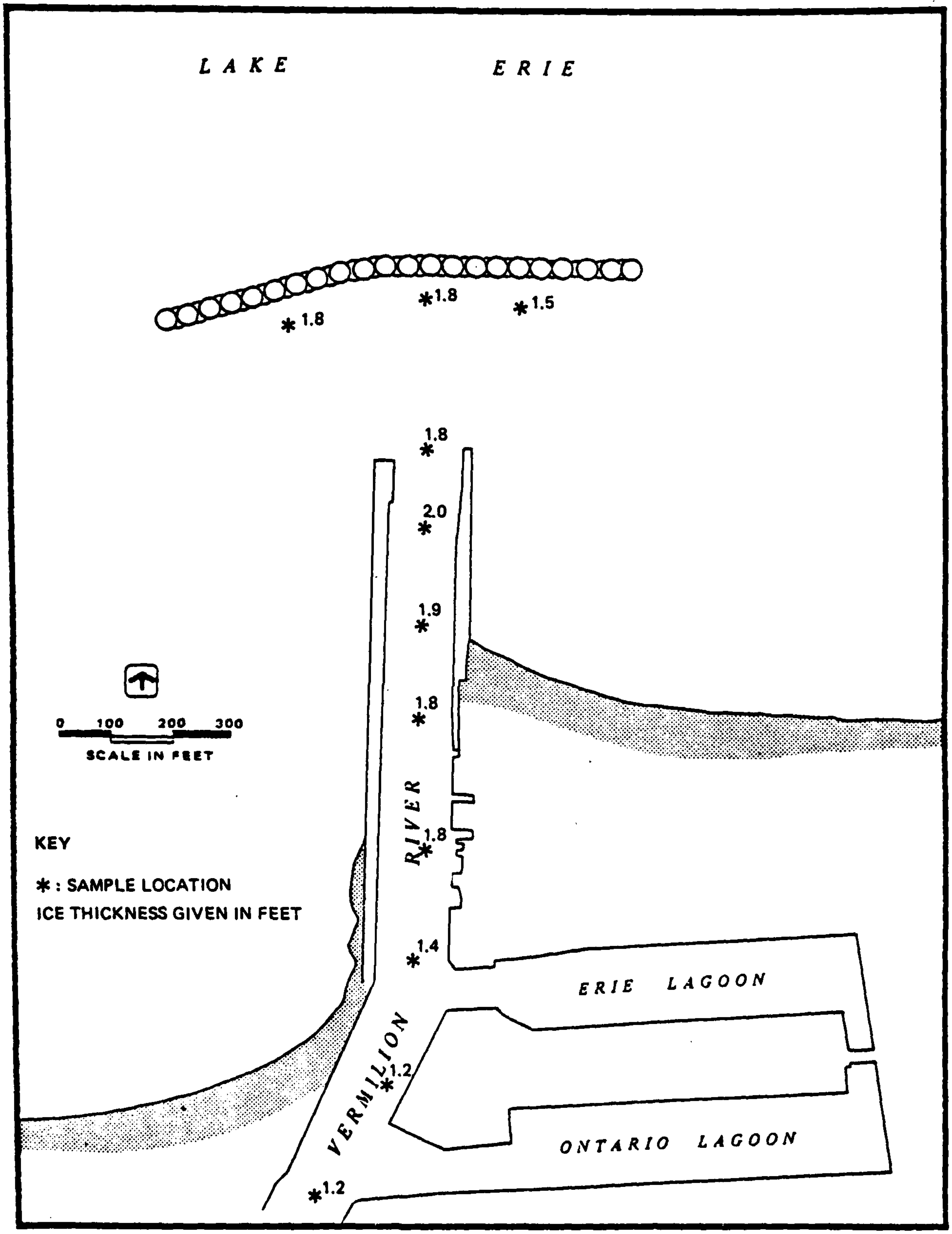
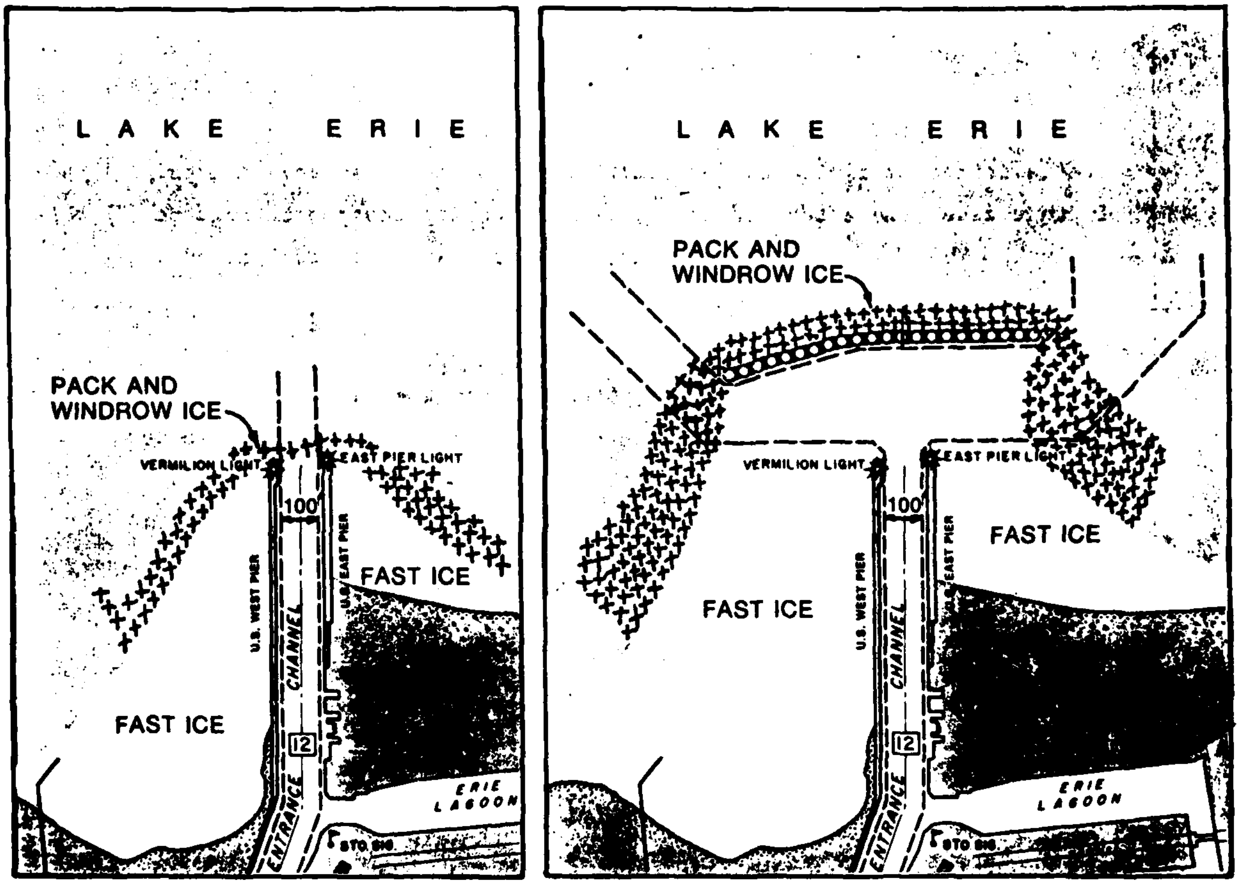



Figure 14 · ICE THICKNESS MAP, VERMILION HARBOR (from Stanley Consultants, 1978)

Photo 12 • SHEET ICE BETWEEN BREAKWATER AND PIERS (Jan. 30, 1978)




Ice conditions before and after construction of the offshore breakwater at Vermilion.

**Figure 15 · EFFECT OF BREAKWATER ON ICE CONDITIONS**

The potential for ice jams and subsequent flooding has long been a problem at Vermilion. Jams may occur either in the river itself, or near the river mouth, as indicated in Figure 11. Jams in the river are caused when ice floes encounter an obstacle or constriction and form a bridge across the river, upon which additional floes accumulate. The critical factors of river flow, channel dimensions and constrictions, ice thickness and ice strength are not affected by the breakwater. The breakwater therefore, does not have a significant impact on the potential for jams in the river channel south of Erie Lagoon.

During some winters, the area between the breakwater and pier ends is still solid sheet ice when the river thaws. This represents the most hazardous ice situation. The flowing ice then hits the fast ice at the pier ends and a jam is initiated between the piers. The breakwater, with fast ice to the piers, effectively catches pack ice driven by easterly winds, creating conditions suitable for windrow formation in the east lake approach channel.

An additional factor influencing ice jam development and subsequent water level rise is the depth of water. If shallow water is present, the ice jam may reach the bottom, creating a "dry jam" (Figure 13) that completely blocks the river flow. This situation may result in serious flooding. The problem of ice jamming was considered in the design of the 1973 harbor improvements. The river channel was dredged to a depth of 8 feet from Huron Street to Liberty Street, as shown on Figure 1. Also observed was the prebreakwater condition where windrowed ice formed at the end of the piers. Under these conditions, only a small amount of area was available under the windrowed ice for water to flow. Postbreakwater conditions cause the windrowed ice to form at the entrance channels, providing more than twice as much area for the water to flow. This can be seen by studying Figure 15. These increased areas will reduce the seriousness of flooding due to ice jams by providing more area for water to flow under the ice. Due to the complexity of ice jams, the extent of these improvements is impossible to quantify.

In summary, the location of potential ice jams in the harbor mouth region has been affected by the breakwater. Jams used to occur at the pier ends; they now occur anywhere from the pier ends to the east end of the breakwater. The primary problem is still to provide an outlet to the lake for the ice. Efforts to provide this path appear to have been hampered by the curved alignment of the new east lake approach channel. The probability of jams occurring is now less than in the prebreakwater period, due to elimination of windrow at the mouth. However, when serious jams occur, local people expect more difficulty in breaking them up.

CONCLUSIONS REACHED BY STANLEY CONSULTANTS (APRIL 1978)

From its studies, Stanley reached the following conclusions regarding the breakwater impact on ice formation, ice development and transport, and breakup and transport from the harbor:

Ice Formation - The breakwater has had very little impact on ice formation in the river channel. The critical factors of temperature and river velocity are not significantly affected by the breakwater. The decrease in

waves and surge may help for an ice cover of uniform thickness. In the harbor mouth area, solid sheet ice is now formed whereas windrows were prevalent prior to the breakwater. The breakwater has to result in thicker ice between the breakwater and the piers than in the river channel.

Ice Development and Transport - Ice growth and transport in the river channel have not been affected. Transport of floes in the vicinity of the breakwater has been significantly altered. Windrows no longer accumulate between the piers, but now often form at the ends of the breakwater.

Spring Breakup and Transport From the Harbor - The breakwater has had no significant impact on ice jaming potential in the river channel upstream of Erie Lagoon. Channel deepening (to 8 feet) of the reach between Huron Street and Liberty Street has reduced the potential for flooding due to ice jams in this area. In the outer harbor area, the location of potential jam spots has been affected. Jams may now form in the east lake approach channel near the breakwater east end, whereas windrows at the ends of the piers used to be the primary jam location. The curved alignment of this channel has made icebreakwater navigation more hazardous, and according to the Coast Guard, it is possible that under unusual circumstances, icebreaking might be impossible. It is also noted that if for any reason the KAW (or similar icebreaker) is not available to assist in breaking up the ice, then the breakwater and associated harbor improvements have had a net beneficial impact on the potential for ice jam flooding.

In summary, Stanley Consultants concluded that the breakwater has had some effect on the potential for ice jam flooding. The probability for ice jams has been reduced due to removal of windrows from the pier ends but the remote possibility of a serious jam not being broken up and resulting in serious flooding now appears to be more viable. It is recommended that additional consideration be given to mitigation of navigation problems related to icebreaking operations by the KAW.

BUFFALO DISTRICT'S EVALUATION AND SUBSEQUENT ACTIONS

To assist in evaluating the breakwater's impact on ice jam flooding, the District requested review of the Vermilion situation by Corps scientists at the Cold Regions Research and Engineering Lab (CRREL). CRREL concluded that the breakwater is an asset for reducing ice jam flooding at the river mouth by creating windrowing further into the lake and allowing a longer diffusion front in deeper water. CRREL also noted that structures similar to the Vermilion breakwater are used at other locations for just this purpose, while cautioning that reduction of ice jam flooding potential does not mean that flooding will not occur in the future. Flooding will occur even under free-flow conditions when the river channel capacity is exceeeded such as happened in July 1969 and at other times before the breakwater was constructed.

On these bases, the Buffalo District concluded that the breakwater has reduced the ice jam flooding potential at Vermilion by eliminating windrowing at the ends of the piers. However, as recommended by Stanley Consultants, the District also concluded that additional consideration should be given to the need for mitigating navigation problems related to icebreaking operations

by the Coast Guard. This analysis was performed by Tetra Tech Inc. under a 1979 contract with the Buffalo District. The Tetra Tech report is presented in its entirety as Appendix B to this report, and summarized below.

Tetra Techs Study of Possible Harbor Modifications to Improve Icebreaking Operations

a. Design Coast Guard Vessels

Upon initiating coordination with the 9th Coast Guard District which performs icebreaking at Vermilion and in other recreational harbors as a service to the communities rather than a designated mission, Tetra Tech found that the Coast Guard was replacing the 110-foot cutters with the larger, more powerful 140-foot class of vessel. As a result, the District modified the contract with Tetra Tech to include evaluation of desired harbor modifications for both the 140-foot vessel (Design Condition 1) and the 110-foot vessel (Design Condition 2).

b. Findings for Design Condition 2 (110-Foot Vessel)

Based on the Coast Guard's past performance, both before and after construction of the breakwater, Tetra Tech concluded that no further harbor modifications are required to permit effective icebreaking operations with the 110-foot cutter at Vermilion Harbor. However, conditions of high river flow and/or the threat of sudden failure of an upstream jam could release a sudden surge of water and ice to the river mouth, possibly forcing a cutter in close proximity against the breakwater, jeopardizing both crew and vessel. Strong southerly winds could produce the same result. As a result, these vessels have not always proceeded into the inner harbor or upriver when hazardous conditions exist, and supplemental icebreaking operations near the river mouth by local officials have been required. Based on these conclusions, alternative designs for modification of Vermilion Harbor to accommodate the 110-foot cutter were not required.

c. Findings for Design Condition 1 (140-Foot Vessel)

This new vessel, which is already operating on the Great Lakes, is expected to replace the 110-foot cutters on the Lakes in the next few years. Since its basic winter mission is to aid commercial navigation during the ice season, these new vessels have no problem in operating in commercial harbors. However, in recreational harbors such as Vermilion and Rocky River on Lake Erie, existing project depths are insufficient for the greater drafts required by the 140-foot icebreakers. With a static draft of 12.5 feet and beam of 37.5 feet, the Coast Guard has stated that a water depth of 15 feet is required for the 140-footers. The existing authorized project depth at Vermilion is 12 feet below Low Water Datum (LWD) or 3 feet less than needed for the 140-footer when the lake level is at LWD. Therefore, additional deepening will be required to allow entry of these new vessels.

Three alternative designs were evaluated to provide harbor access by the 140-foot icebreaker:

Alternative 1 - Deepening of existing channels;

Alternative 2 - Breaching of the breakwater, and deepening of appropriate channels; and,

Alternative 3 - Removal of the breakwater, and deepening of the entrance channel.

Figures 16, 17, and 18 show the plan view for Alternatives 1 through 3, respectively. Associated quantities, costs, and beneficial and adverse effects of each of these alternatives are discussed in Chapter 4 of Appendix B. Table 9, provides a qualitative comparison of the alternatives, based on functional/engineering, environmental, economic, and acceptability criteria. From the matrix, Alternative 1, Route 2 (deepening of the East Entrance Channel only) ranks highest overall, followed closely by Alternative 4, the "No-Action" alternative. With a 200-foot wide entrance channel widening into a turning basin at its southerly limit, the total first cost for Alternative 1, Route 2, would be approximately $187,000. Annual maintenance for the total harbor project (7,450 cy/year) would be approximately $87,000, with the additional dredging required specifically for the 15-foot project approximately 1,650 cy/year, or about $20,000 of the total of $87,000. As would be expected, Alternatives 2 and 3 would produce adverse wave conditions at the harbor and river entrances, thus adversely affecting recreational navigation at Vermilion Harbor. Based on consideration of both positive and negative aspects of the alternative plans, Tetra Tech concluded that Alternative 1, Route 2, best serves the objective of providing improvements needed for icebreaking operations at Vermilion Harbor the the new 140-foot vessel.

## CONCLUSIONS REACHED BY BUFFALO DISTRICT

### Design Condition 2 (110-Foot Vessel)

The District concludes that no channel or harbor modification is required to allow icebreaking activities to be successfully undertaken when employing the 110-foot vessel. The Coast Guard has shown that the 110-foot cutter can enter the harbor to perform icebreaking operations. The winter of 1980 showed the ability of the 110-foot ARUNDEL to safely navigate through the harbor entrance and proceed upriver to near the head of navigation under favorable river and weather conditions. This serves to indicate that if the 110-foot vessel was still available for icebreaking in Vermilion Harbor, no channel or structural modification of the Federal navigation works at Vermilion would be required.

### Design Condition 1 (140-Foot Vessel)

The Coast Guard icebreaking fleet on Lake Erie is presently in a state of change. The Coast Guard has indicated that the traditionally used 110-foot cutter will no longer be available to serve the future needs of the city of

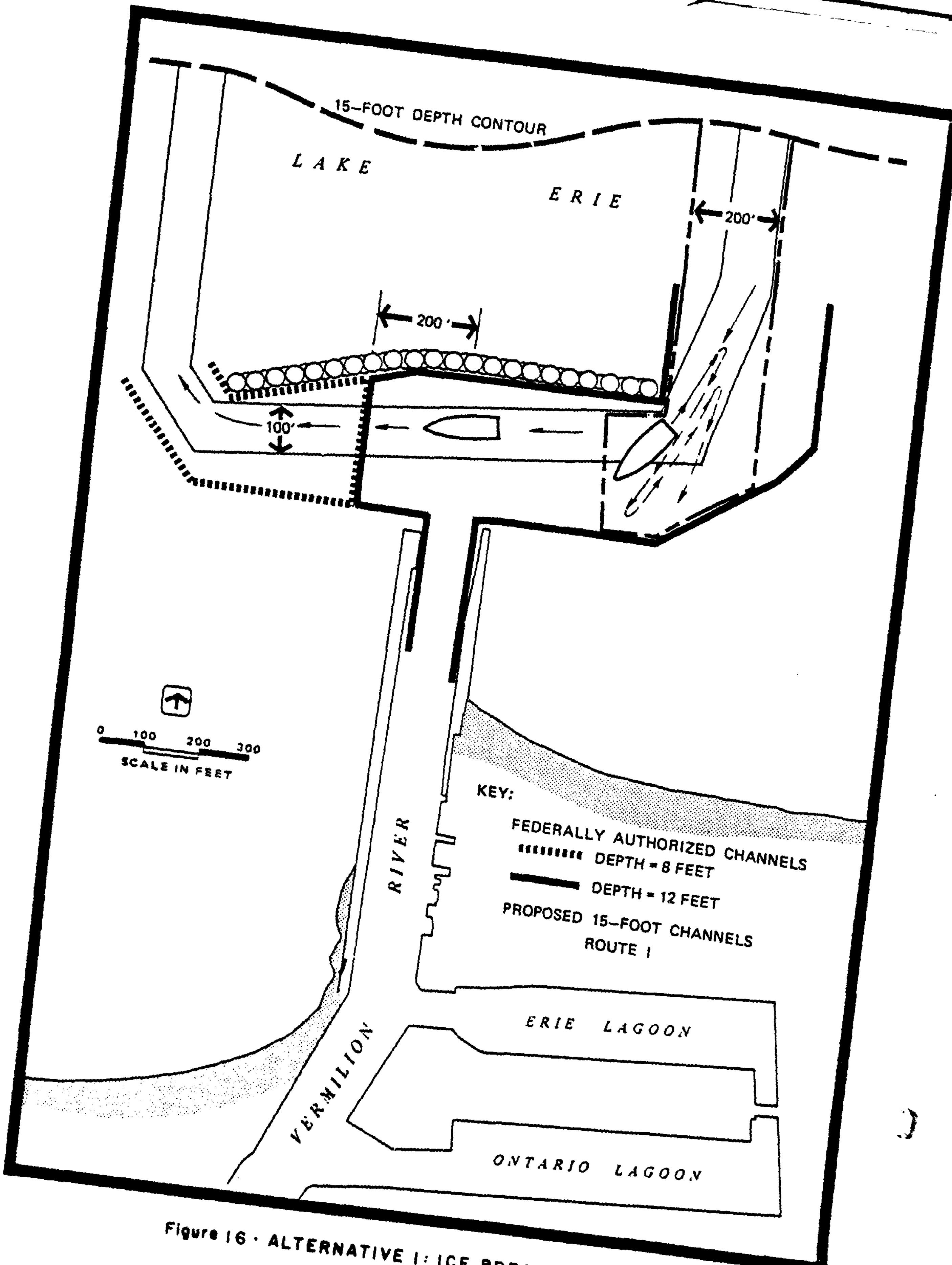



Figure 16 · ALTERNATIVE I: ICE BREAKER ROUTES

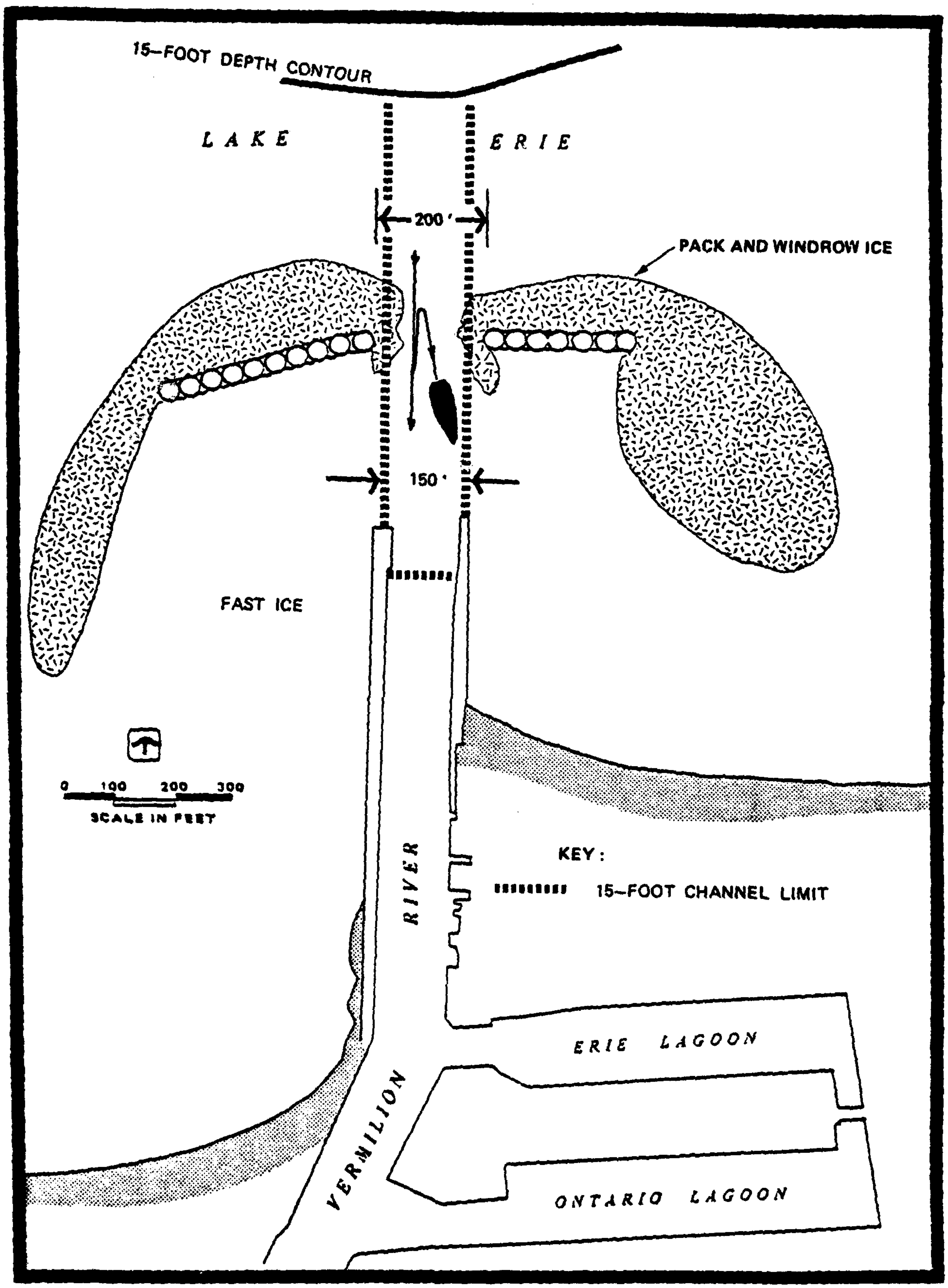



Figure 17· ICE LOCATION AND ICEBREAKER ROUTE-ALTERNATIVE 2

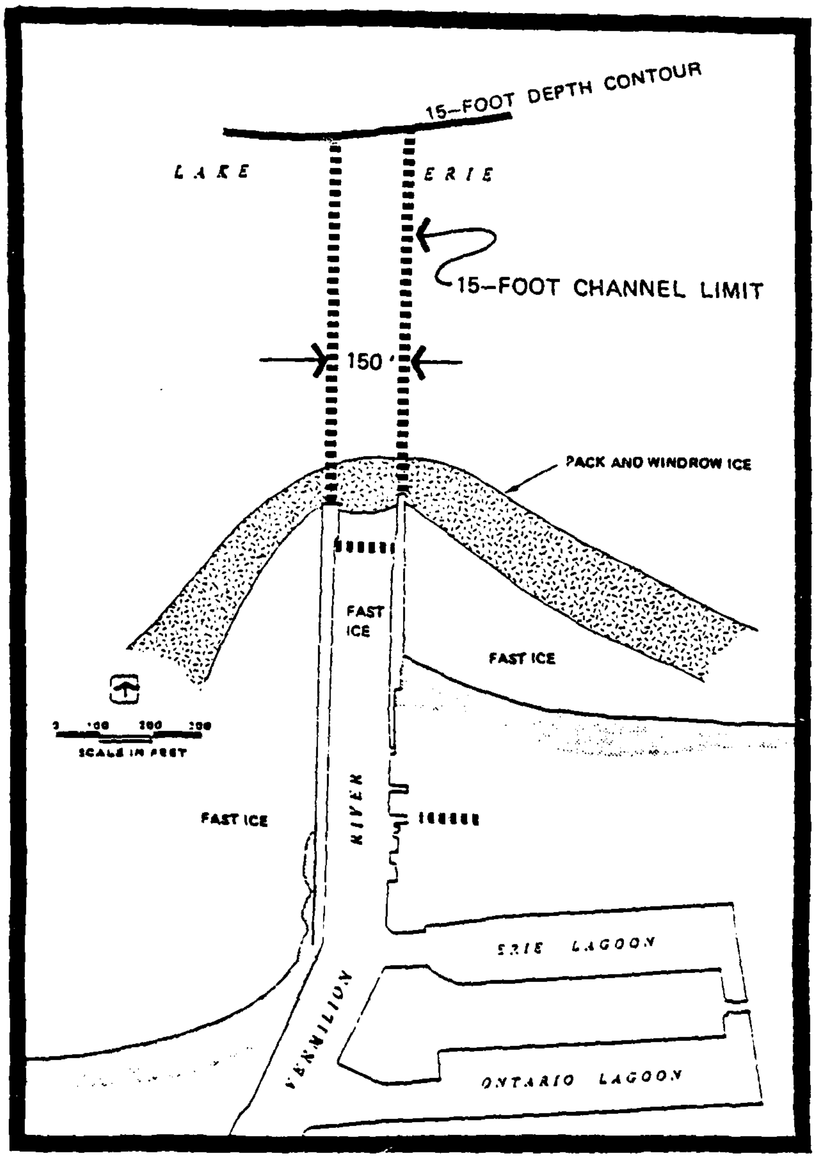



Figure 18 · : ALTERNATIVE 3, REMOVE BREAKWATER AND DEEPEN CHANNEL

Table 9 - Evaluation Matrix

| Alternative | Description | | FUNCTIONAL/ENGINEERING: Ice Jam Mitigation | Coast Guard Icebreaker Nav Safty | Ice Free Periods Nav Safty | Sedimentation | Construction Feasibility | Subtotal | ENVIRONMENTAL: Beach Stability | Water Quality | Aesthetics | Subtotal | ECONOMIC: Construction Cost | Maintenance Cost | Subtotal | ACCEPTABILITY: Local | Agency | Subtotal | Score | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | 8 | 7 | 8 | 6 | 8 | - | 7 | 7 | 5 | - | 7 | 7 | - | 9 | 7 | - | | |
| 1 | Deepen Channel | R | 2 | 2 | 3 | 1 | 1 | - | 1 | 2 | 1 | - | 1 | 1 | - | 2 | 1 | - | 133 | 3 |
| | Route I | IR | 16 | 14 | 24 | 6 | 8 | 89 | 7 | 14 | 5 | 26 | 7 | 7 | 14 | 18 | 7 | 25 | | |
| | | R | 2 | 2 | 3 | 1 | 2 | - | 1 | 2 | 1 | - | 2 | 2 | - | 2 | 3 | - | | |
| | Route II | IR | 16 | 14 | 24 | 6 | 16 | 97 | 7 | 14 | 5 | 26 | 14 | 14 | 28 | 18 | 21 | 39 | 169 | 1 |
| 2 | Breach Breakwater | R | 2 | 2 | 1 | 2 | 1 | - | 2 | 3 | 1 | - | 1 | 2 | - | 1 | 1 | - | 145 | 4 |
| | and Deepen | IR | 16 | 14 | 8 | 12 | 8 | 75 | 14 | 21 | 5 | 40 | 7 | 14 | 21 | 9 | 7 | 16 | | |
| 3 | Remove Breakwater | R | 1 | 0 | 1 | 2 | 2 | - | 2 | 3 | 2 | - | 0 | 2 | - | 2 | 1 | - | 128 | 5 |
| | (only) | IR | 8 | 0 | 8 | 12 | 16 | 44 | 14 | 21 | 10 | 45 | 0 | 14 | 14 | 18 | 7 | 25 | | |
| 4 | No Action | R | 1 | 0 | 3 | 1 | 3 | - | 1 | 2 | 1 | - | 3 | 2 | - | 2 | 3 | - | 162 | 2 |
| | | IR | 8 | 0 | 24 | 6 | 24 | 83 | 7 | 14 | 5 | 26 | 21 | 14 | 35 | 18 | 21 | 39 | | |

Vermilion. This vessel, which has shown its effectiveness and ability to conduct safe and efficient icebreaking operations in the authorized 12-foot depths of Vermilion Harbor, will soon be replaced by a larger, faster, more efficient 140-foot vessel class.

This should provide more effective icebreaking capability in the commercial shipping lanes, which is the primary objective of the Coast Guard icebreaking program. The larger 140-foot class icebreaker has a 12.5-foot draft and requires a 15-foot water draft for safe icebreaking operation. The Vermilion Harbor Channel has been Federally authorized to be maintained at a depth of 12 feet in the River and Harbors Act of 1875 for commercial fishing. Therefore, if the channel is not deepened, the vessel could not break ice at Vermilion unless a relatively high lake level (571.6 feet, IGLD) existed. Based on historical lake level information, the 571.6-foot lake level has existed throughout the January-March period only 5 times in the last 60 years. Thus, unless the entrance channel to Vermilion is deepened beyond the 12-foot authorized depth, it is expected that the new 140-foot Coast Guard icebreaking vessel cannot be used routinely. Therefore, the District concludes that additional project depth should be provided at Vermilion Harbor to permit continued icebreaking operation by the new 140-foot vessel.

<u>Authority for Possible Modifications to Accommodate Larger Coast Guard Vessels for Icebreaking Purposes</u>

It is concluded that Congressional authorization will be required to perform additional deepening from -12 feet LWD to -15 feet LWD in the East Entrance Channel. The appropriate legislature authority is Section 216 of Public Law 91-611 (River and Harbor and Flood Control Act of 1970) which authorizes review of and report to Congress on the operation of completed projects when found advisable due to significantly changed physical or economic conditions. This report to Congress would be in the form of a separate letter report for modification of the existing navigation project due to changed icebreaking operations by the U.S. Coast Guard.

BUFFALO DISTRICT'S RECOMMENDATIONS

It is recommended that no further study of the effect of the detached breakwater on ice-jam flooding be made. However, because of changed conditions consisting of a program by the U.S. Coast Guard to replace the 110-foot cutters now operating on the Great Lakes with larger 140-foot vessels, it is further recommended that consideration be given to deepen or otherwise modify the Vermilion Harbor project to accommodate these larger vessels. The appropriate authority to obtain Congressional Authorization to modify Vermilion Harbor, if required, is Section 216 of PL 91-611. The reporting document to Congress would be in the form of a letter report prepared specifically for this purpose.

# FREE - FLOW FLOODING

INTRODUCTION

The Vermilion River has a history of flooding so severe that within a 5-year period the Buffalo District published two reports pertaining to magnitude, frequency, and prevention of future floods. The first study report was published in 1965, long before the breakwater was constructed. This study was requested by the state of Ohio because the Vermilion River had a history of serious flooding. Concerned local and State agencies realized the need for a report which summarized past flooding and predicted the magnitude and frequency of future floods. The report was to provide a means by which the hazards and damages from future floods could be anticipated and reduced, and to provide a tool for sound flood plain management. The second report, covering the record flood of July 1969, also predated the breakwater. Based on available high water marks, the 1969 flood reached higher elevations than a 1913 flood, which had been the greatest historical flood. Because the 1969 event was so large, the Buffalo District prepared the report to emphasize the hazards of a major flood, and to warn that future development in the flood plain would result in larger damages unless that development was undertaken with a knowledge of flooding problems in the area. Since the detached breakwater was completed in 1973, residents near the lower reach of the river have implied that the structure increases the flood potential by raising the flood profile. This section will evaluate the impact of the detached breakwater on free flow flooding by analyzing both the hydraulic conditions in the vicinity of the breakwater and the change in water level at the river mouth. The study of free-flow conditions was performed by Stanley Consultants and the results presented in Chapter 6 of the April 1978 Breakwater Impact Study Report.

HYDRAULIC ANALYSIS

Reference Datum

All the elevations used in this section are measured from National Geodetic Vertical Datum of 1929 (NGVD-1929). These values are 1.6 feet above corresponding levels based on International Great Lakes Datum, 1955 (IGLD-1955). For example, an elevation of 569.6 (NDVD Datum) is equal to 568.0 (IGLD).

Hydraulic Criteria

In order to evaluate the effects of the detached breakwater on flooding, Stanley Consultants utilized several sets of factors:

- Discharge Data:
  - Values used in the 1977 Flood Insurance Study
  - Revised values of the above FIS data.

- Lake Levels:

  - 569.6 feet (NGVD) - an extremely low value. The monthly mean level of Lake Erie has dropped to, or fallen below, elevation 569.6 only four different times in over 100 years. Therefore, the chances of any lower level coinciding with a flood on the Vermilion River are very slight.

  - 572.0 feet (NGVD) - an average level. This is close to the arithmetic average of all lake levels since 1860.

  - 575.9 feet (NGVD) - a high level. This corresponds to a lake level with a recurrence interval of about 20 years on an instantaneous basis. As in the case of the low level, the chances of a lake level higher than 575.9 coinciding with a flood on the Vermilion River are very slight. Analysis of this condition is the most critical, since it is during periods of high lake levels that the potential for damaging floods is highest.

- Channel Bed Conditions:

  - Both approach channels at design depth and width.

  - The east approach channel silted to such a degree as to be identical to conditions prior to dredging in that area in 1973. The west channel filled to such a degree as to be identical to conditions prior to dredging in that area in 1976. This was considered to be the most adverse state.

- Distribution of total peak discharge:

  - All flow passes through west approach channel.

  - All flow passes through east channel.

  - The flow splits in such a manner that water velocity is the same in both channels.

<u>Methodology</u>

For each of the three critical lake levels, the increase in flood elevation at the entrance channel mouth (Location B on Figure 19) was manually computed for a wide range of possible flows in the channel. Computations showed that, the lower the flow, the smaller the increase in water surface elevation at Location B. Table 10 lists the water surface elevation at the mouth for a range of river flows, both with and without the breakwater. In order to determine the maximum flow that can be conveyed in the entrance channel, a series of step-backwater (backwater) computations using Manning's equation were made, beginning at the mouth of the channel at Location B. A range of discharges was considered for each lake level. Starting water surface elevations were set equal to the lake level plus the increase caused by the breakwater. The largest flow which could be contained within the

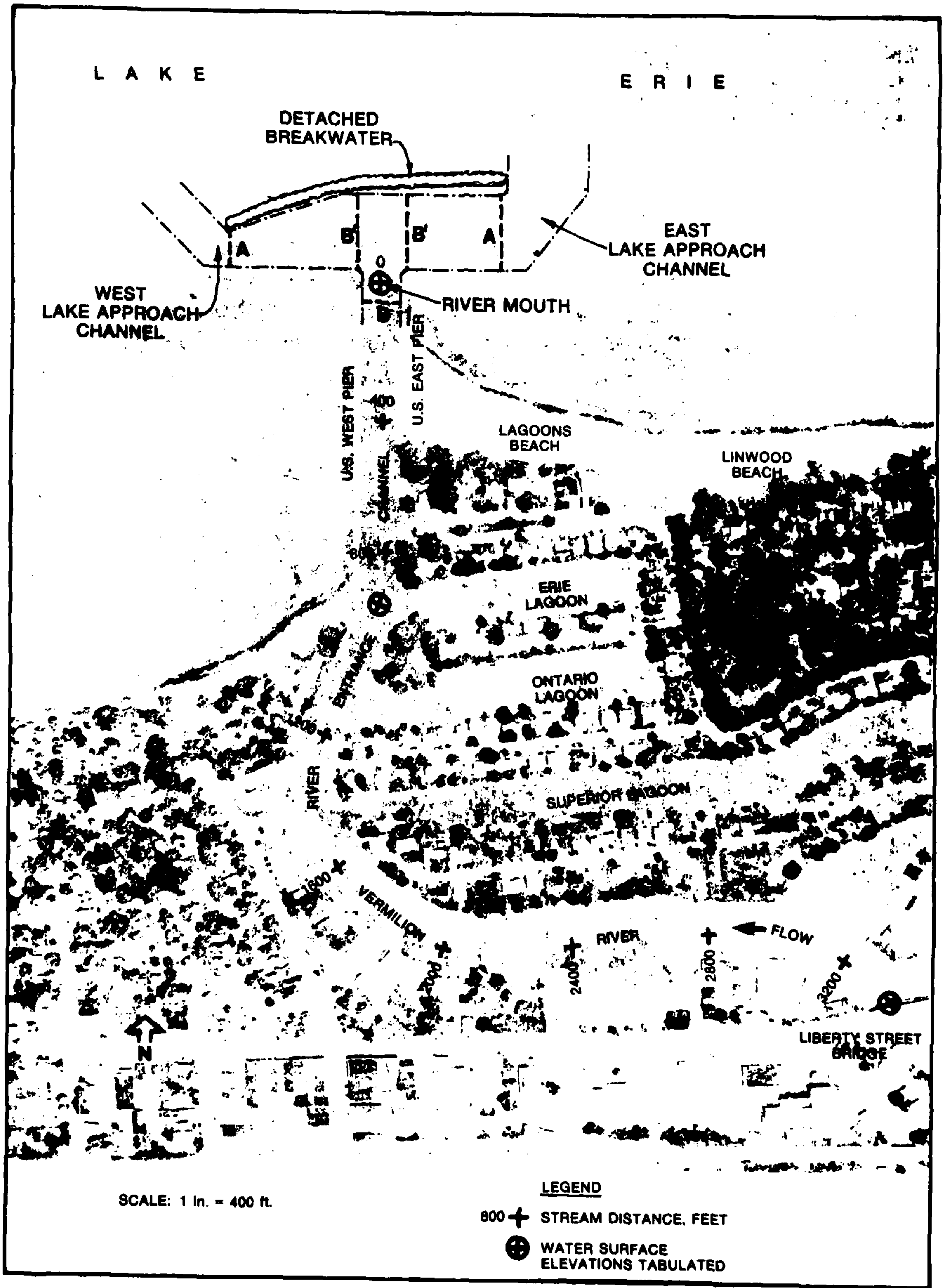



**Figure 19 • PLAN VIEW OF BREAKWATER VICINITY**

Table 10 - Flood Profile Elevations at the Harbor Mouth (4)

| Source of Peak Discharge | Frequency (yr) | Discharge (cfs) | Flood Profile Elevation Lake Level (NGVD-1929) 569.60 Without Breakwater (ft) | 569.60 With Breakwater (ft) | 572.00 Without Breakwater (ft) | 572.00 With Breakwater (ft) | 575.90 Without Breakwater (ft) | 575.90 With Breakwater (ft) |
|---|---|---|---|---|---|---|---|---|
| Updated Analysis | 10 | 14,900 | 569.60 | 569.70 | 572.00 | 572.10 | 575.90 | 576.00 (3) |
| | 50 | 28,700 | 569.60 | 569.90 (1) | 572.00 | 572.20 (2) | 575.90 | 576.00 (3) |
| | 100 | 37,300 | 569.60 | 569.90 (1) | 572.00 | 572.20 (2) | 575.90 | 576.00 (3) |
| | 500 | 67,800 | 569.60 | 569.90 (1) | 572.00 | 572.20 (2) | 575.90 | 576.00 (3) |
| 1977 FIA Study | 10 | 14,500 | 569.60 | 569.70 | 572.00 | 572.10 | 575.90 | 576.00 (3) |
| | 50 | 25,000 | 569.60 | 569.90 | 572.00 | 572.20 | 575.90 | 576.00 (3) |
| | 100 | 31,500 | 569.60 | 569.90 (1) | 572.00 | 572.20 (2) | 575.90 | 576.00 (3) |
| | 500 | 50,000 | 569.60 | 569.90 (1) | 572.00 | 572.20 (2) | 575.90 | 576.00 (3) |

(1) Only 27,500 cfs will be affected by the breakwater.

(2) Only 27,000 cfs will be affected by the breakwater.

(3) Only 14,000 cfs will be affected by the breakwater.

(4) Stanley Consultants, April 1978.

entrance channel without overtopping the West Pier or west bank would be the one with the largest rise in floodwater elevations which would be created by the breakwater.

Backwater analyses at each lake level were also conducted for peak discharges which were larger than the maximum peak discharge which could be affected by the breakwater. These analyses were begun at the point at which water in excess of the maximum peak discharge flows over the West Pier. The total backwater analysis, therefore, considers the maximum peak channel discharge from the river mouth to the point of overflow, and the total flood flow from this point upstream.

## EFFECT OF THE BREAKWATER ON RIVER FLOOD ELEVATIONS

From review of the Flood Insurance Study and preliminary calculations, it was concluded that at each of the three studied lake levels the harbor entrance channel has some maximum capacity of flow which would cause water to overtop the West Pier (Figure 20). These calculations also indicated channel bed conditions of both the east and west approach channels had a negligible effect on flood levels.

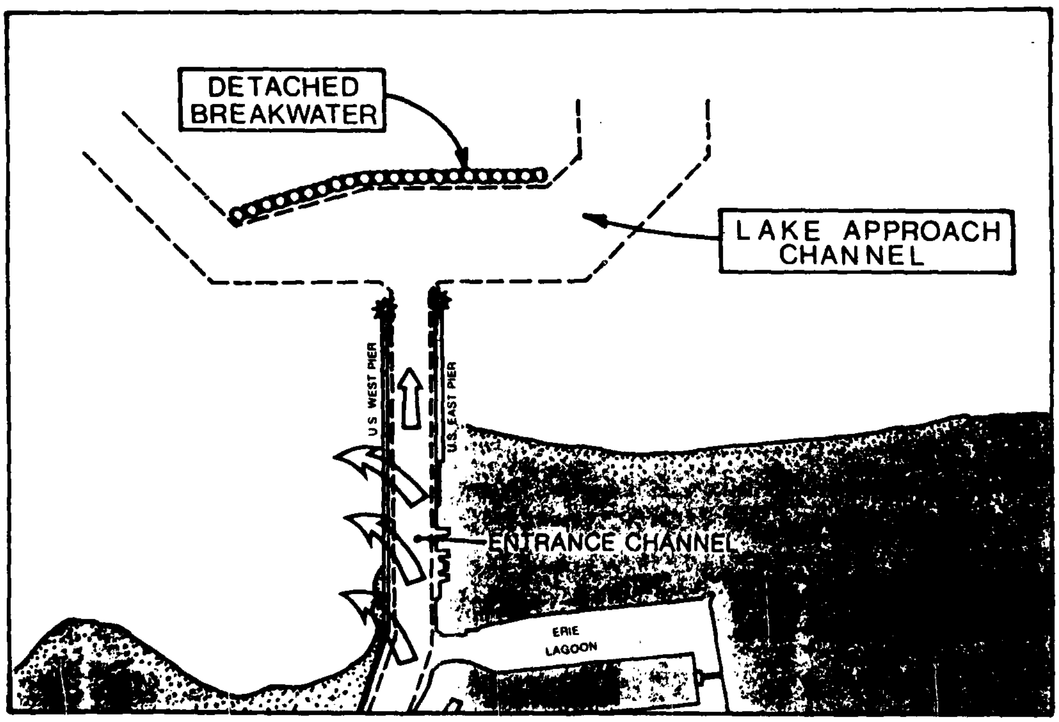



Figure 20 • FLOODWATER PATHS

By trial and error, the maximum channel capacity before overtopping the West Pier was determined for each of the three levels (Table 11).

Table 11 - Peak Discharges and Lake Levels Considered

| Peak Vermilion River Discharges | | Lake Erie Levels | | |
|---|---|---|---|---|
| Recurrence Interval (Years) | Peak Discharge (cfs) | Recurrence Interval (Years) | Lake Level IGLD-1955 | Lake Level IGLD-1929 |
| 10 | 14,900 | 1 | 568.0 | 569.6 |
| 50 | 28,700 | 2 | 570.4 | 571.0 |
| 100 | 37,300 | 20 | 574.3 | 575.9 |
| 500 | 67,800 | | | |

On the basis of these computations, backwater calculations were made for various combinations of river discharge and coincident lake level. As shown in Table 10, it was found that the maximum increase in flood level due to the breakwater would occur near the ends of the piers (Location B on Figure 19), and would range between 0.1 and 0.3 foot, depending on the flow and lake stage. Tables 12, 13 and 14 provide a summary comparison of the water surface elevations at three locations for various Lake Erie stages and Vermilion River discharges both with and without the breakwater. Near the downstream limit of the residential development at Erie Lagoon (Table 12), the maximum increase in water level would be approximately 0.1 foot. Further upstream near the Liberty Avenue Bridge, the maximum increase for the most critical combination of river flow and lake stage is further reduced to about 0.05 foot (Table 13). Further upstream at State Route 2 the breakwater has no effect on the water surface elevation (Table 14).

CONCLUSIONS

Based on the studies performed by Stanley Consultants, it is concluded that the detached breakwater has a negligible effect on free-flow flooding in the developed areas along the Vermilion River. Therefore, no further consideration of mitigation for free-flow flooding is warranted.

However, it must be recognized that flooding along the river will occur when the river channel capacity is exceeded such as happened in July 1969 and at other times before the breakwater was constructed.

Table 12 - Flood Profile Elevations at the Erie Lagoon Mouth (1)

| Source of Peak Discharge | Frequency | Discharge | Flood Profile Elevation Lake Level (NGVD-1929) 569.60 Without Breakwater | 569.60 With Breakwater | 572.00 Without Breakwater | 572.00 With Breakwater | 575.90 Without Breakwater | 575.90 With Breakwater |
|---|---|---|---|---|---|---|---|---|
| | (yr) | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) |
| Updated Analysis | 10 | 14,900 | 572.06 | 572.10 | 573.34 | 573.41 | 576.65 | 576.75 |
| | 50 | 28,700 | 578.33 | 578.33 | 578.38 | 578.40 | 578.38 | 578.46 |
| | 100 | 37,300 | 580.37 | 580.37 | 580.91 | 580.92 | 580.91 | 580.92 |
| | 500 | 67,800 | 584.24 | 584.24 | 584.22 | 584.22 | 584.19 | 584.19 |
| 1977 FIA Study | 10 | 14,500 | 571.93 | 571.97 | 573.27 | 573.34 | 576.63 | 576.74 |
| | 50 | 25,000 | 576.61 | 576.61 | 576.87 | 576.92 | 577.62 | 577.72 |
| | 100 | 31,500 | 578.72 | 578.72 | 579.13 | 579.14 | 579.13 | 579.17 |
| | 500 | 50,000 | 582.48 | 582.48 | 582.48 | 582.48 | 582.50 | 582.50 |

(1) Stanley Consultants, April 1978.

Table 13 - Flood Profile Elevations Just Below Liberty Avenue (1)

| Source of Peak Discharge | Frequency | Discharge | Flood Profile Elevation Lake Level (NGVD-1929) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 569.60 | | 572.00 | | 575.90 | |
| | | | Without Breakwater | With Breakwater | Without Breakwater | With Breakwater | Without Breakwater | With Breakwater |
| | (yr) | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) |
| Updated Analysis | 10 | 14,900 | 576.43 | 576.44 | 576.70 | 576.72 | 578.00 | 578.05 |
| | 50 | 28,700 | 580.70 | 580.70 | 580.71 | 580.72 | 580.71 | 580.73 |
| | 100 | 37,300 | 582.39 | 582.39 | 582.63 | 582.64 | 582.63 | 582.64 |
| | 500 | 67,800 | 586.44 | 586.44 | 586.42 | 586.42 | 585.41 | 585.41 |
| 1977 FIA Study | 10 | 14,500 | 576.27 | 576.27 | 576.55 | 576.57 | 577.93 | 577.98 |
| | 50 | 25,000 | 579.76 | 579.76 | 579.80 | 579.81 | 579.97 | 579.99 |
| | 100 | 31,500 | 581.18 | 581.18 | 581.30 | 581.30 | 581.30 | 581.32 |
| | 500 | 50,000 | 584.40 | 584.40 | 584.40 | 584.40 | 584.40 | 584.40 |

(1) Stanley Consultants, April 1978.

Table 14 - Flood Profile Elevations Just Below State Route 2

| Source of Peak Discharge | Frequency (yr) | Discharge (cfs) | Flood Profile Elevation Lake Level (NGVD-1929) 569.60 Without Breakwater (ft) | 569.60 With Breakwater (ft) | 572.00 Without Breakwater (ft) | 572.00 With Breakwater (ft) | 575.90 Without Breakwater (ft) | 575.90 With Breakwater (ft) |
|---|---|---|---|---|---|---|---|---|
| Updated Analysis | 10 | 14,900 | 596.72 | 596.72 | 596.72 | 596.72 | 596.73 | 596.73 |
| | 50 | 28,700 | 601.68 | 601.68 | 601.68 | 601.68 | 601.68 | 601.68 |
| | 100 | 37,300 | 604.03 | 604.03 | 604.03 | 604.03 | 604.03 | 604.03 |
| | 500 | 67,800 | 610.37 | 610.37 | 610.37 | 610.37 | 610.37 | 601.37 |
| 1977 FIA Study | 10 | 14,500 | 596.54 | 596.54 | 596.54 | 596.54 | 596.54 | 596.54 |
| | 50 | 25,000 | 600.51 | 600.51 | 600.51 | 600.51 | 600.51 | 600.51 |
| | 100 | 31,500 | 602.50 | 602.50 | 602.50 | 602.50 | 602.50 | 602.50 |
| | 500 | 50,000 | 606.96 | 606.96 | 606.96 | 606.96 | 606.96 | 606.96 |

# SEDIMENTATION

## INTRODUCTION

Sedimentation accumulation in the Vermilion River and the adjoining Lagoons has been an area of concern to the residents of Vermilion. Residents contend that the breakwater has altered the transport of sediments in the river and outer harbor.

The purpose of this study is to determine what impact the detached breakwater has on this process in the Vermilion River and Lagoons located north of the Liberty Street (Highway 6) bridge. The study was performed by Stanley Consultants under contract to the Buffalo District. This section summarizes the study results, and provides the Buffalo District's conclusion regarding the need for mitigation of this impact due to construction of the offshore breakwater.

The drainage area of the Vermilion River includes 272 square miles located in parts of five Ohio counties. Land use is primarily agricultural with several large communities. Eroded soil from these regions wash into the river and are carried along with the flow as long as the velocity is high enough to keep the sediment particles in suspension. In the areas of the Vermilion River where the river gradient flattens out, the velocity will decrease and the larger, heavier soil particles will settle to the channel bottom. The natural backwater effect of Lake Erie enhances sedimentation in the river, harbor, and Lagoon area by reducing the hydraulic gradient and slowing the velocity of the river flow so that, under natural conditions, sediment buildup in the river will vary from year to year.

The two primary sources of sediment in the Vermilion River are solids discharged from sewage treatment plants and eroded soil. The amount of suspended solids from the Vermilion sewage treatment plant is approximately 25 tons per year and is negligible when compared to an average of about 125,000 tons of suspended sediment load per year in the Vermilion River.

The sediment load in the river is dependent on the river flow. During low flow periods, most of the water in the river comes from ground water sources, and the sediment load is relatively low. During high flow periods, most of the water in the river will come from overland runoff following storms, and the water contains high concentrations of sediment. These higher sediment concentrations combined with the higher flow will result in sediment loads transported by the river increasing at a rate much faster than the increase in river flow. High river flows will therefore carry proportionally much higher sediment loads than low flows.

## HISTORY OF SEDIMENT ACCUMULATION

Prior to the construction of the detached breakwater in 1973, maintenance dredging of Vermilion Harbor (including the Vermilion River portion) was infrequently performed. Prior to 1874, the entrance channel was maintained to the 8-foot depth. Since 1874, the entrance channel has been maintained to approximately the 12-foot authorized project depth. Since construction of

the breakwater, maintenance harbor dredging has been performed a number of times. The history of the dredging program, both before and after construction of the breakwater in 1973, is summarized below.

Dredging Prior to Breakwater Construction in 1973

Sediment buildup in the Vermilion River has caused interference with navigation during past years and several dredging projects have been undertaken. Between 1874 and 1878, the piers were extended to their present location in Lake Erie and the river was dredged to a depth of 12 feet for a distance of approximately 1,335 feet upstream from the outer ends of the entrance piers. During 1915 and 1916, the entrance channel was dredged by the Federal Government to 12-foot depth and local interests dredged the river channel upstream from the Federal project limit. Between 1930 and 1937, dredging upstream of the Federal project to the vicinity of the Liberty Street bridge was undertaken by private interests. During 1935, shoal material was dredged from the entrance to the river channel. No record of additional major dredging projects in the river channel are encountered until 1969, when a large shoal was removed from the channel entrance following the July 1969 flood.

The Erie, Ontario, Superior, and Huron Lagoons, constructed by private interests, were completed in 1933. Silt accumulated in the lagoons over a period of years and was causing some problems with navigation as early as 1950. In 1955, a permit was obtained from the Corps of Engineers to dredge the lagoons; however, the actual dredging was not accomplished until 1959 when the lagoons were dredged to a depth of approximately 8 feet below low water datum (IGLD 568.6).

The data indicates that sediment deposition in the lagoons has been occurring since the lagoons were constructed in 1933. Sediment buildup varies from year to year depending upon the suspended sediment load carried in the river during a given year.

Shallow areas exist near the mouths of the lagoons and near the shore around some of the bends. It is anticipated that these shoals may interfere with navigation. When water enters the lagoons from the river, the velocities decrease substantially. This causes the larger sediment particles carried in the water to settle out near the mouth of the lagoon thereby causing the high sediment buildup in these areas. Sediment buildup near the shoreline and around curves occurs in quiet areas where velocities are significantly reduced.

Dredging Subsequent to Breakwater Construction in 1973

During 1973 and 1974, the offshore breakwater was constructed and the East and West Lake Approach Channels were dredged to the depths shown in Figure 21.

Table 15 summarizes the history of dredging operations at Vermilion Harbor during and after construction of the breakwater in 1973. From the tablulation it is seen that maintenance dredging has been performed on five

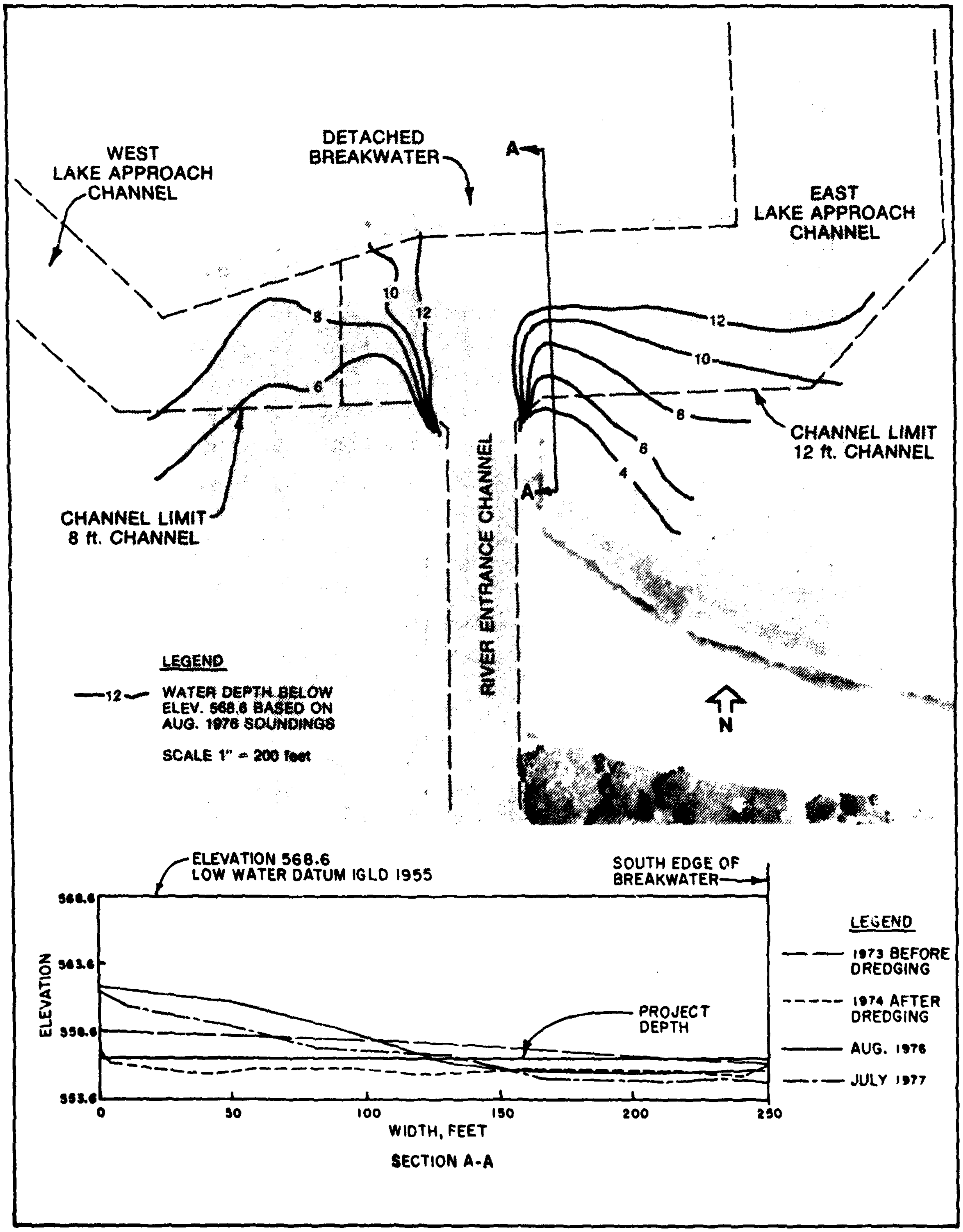



Figure 21 • **SEDIMENTATION IN LAKE APPROACH CHANNELS**

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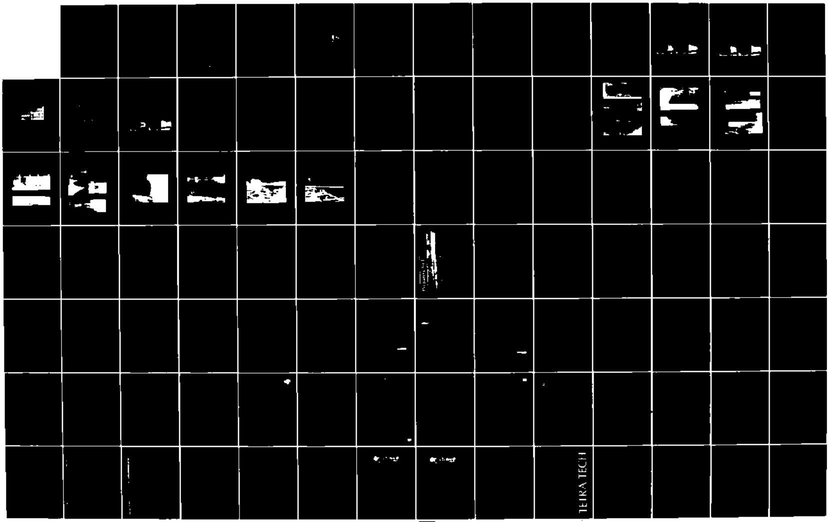

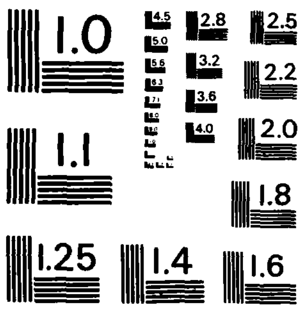


MICROCOPY RESOLUTION TEST CHART
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separate occassions since 1973. No dredging was performed in 1980 and none is scheduled for 1981.

Table 15 - Dredging History at Vermilion Harbor Since Completion of Breakwater in 1973

| | Date Purpose of Dredging | Volume Dredged (c.y.) | Total Cost | Cost/Cubic Yard At Time of Dredging | Cost/Cubic Yard Escalated to 1980 P.L. | Disposal Location |
|---|---|---|---|---|---|---|
| | | | $ | $ | $ | |
| 1. | Sep-Dec 1973 (Harbor Mod) | 25,000 | 187,900 | 7.30 | 12.20 | Land & deepwater |
| 2. | June 1974 (Maintenance) | 5,900 | 24,000 | 4.10 | 6.30 | Beach on west side of harbor |
| 3. | February 1975 (Maintenance) | 3,000 | 10,300 | 3.40 | 5.40 | Beach on west side of harbor |
| 4. | Nov-Dec 1975 (Maintenance) | 10,850 | 53,200 | 4.90 | 7.20 | Nakomis Beach, east of harbor and deepwater disposal |
| 5. | 1978 (Maintenance) | 3,496 | 18,000 | 5.15 | 6.23 | Deepwater disposal |
| 6. | Oct-Nov 1979 (Maintenance) | 23,000 | 147,200 | 6.40 | 7.00 | Deepwater disposal |

Figure 22 shows the harbor areas where high sediment buildup tends to occur and maintenance dredging is most concentrated.

Sediment buildup along the pier at the east edge of the river entrance channel in the eastern lake approach has been an area of concern during the years of 1973 through 1975 as evidenced by the two emergency dredging operations which were undertaken in 1974 and 1975. The sediment along the east edge of the channel consisted primarily of beach sand blown or washed over the east pier during northeasterly storms. Large stone blocks were placed on top of a portion of the east pier in August 1974 to reduce sand movement into the river channel. The large stone blocks were not immediately effective and emergency dredging was required after their installation in 1975. This area has not needed emergency dredging since 1975, therefore it is assumed that the stones placed in 1975 have had a beneficial effect and the problem has stabilized. Routine maintenance dredging between the piers and upriver to the upstream limit of the project was undertaken in 1979.

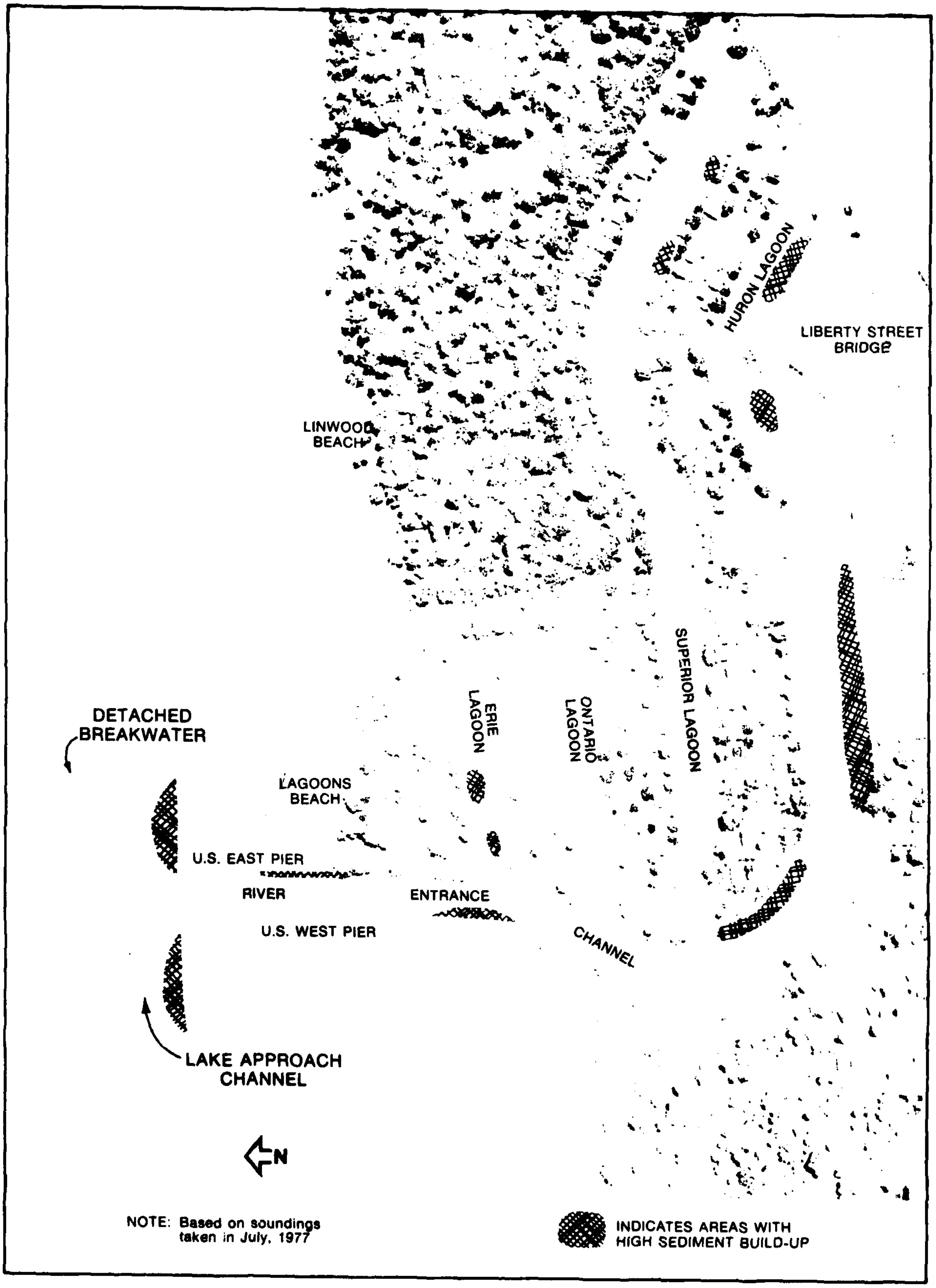



**Figure 22 • AREAS OF SEDIMENTATION**

## SEDIMENT COMPOSITION

Sediment samples of the lake approach channels and the river channel were collected by Stanley Consultants during August 1976 and May - August 1977. The samples collected by Stanley Consultants were analyzed for grain size and organic content.

Sample locations for the 1976 and 1977 sampling are shown in Figure 23, while material classification and organic content are shown in Table 16. Examination of the results in Table 16 reveal that samples collected from the Vermilion River upstream of the piers consist of silt and clay sized particles. Analysis of samples collected in the lake approach channels between the river piers and the detached breakwater indicates that material deposited in this area consists primarily of silt and clay sized particles and therefore is of river origin. Some sand was encountered immediately northeast of the end of the east pier and immediately northwest of the end of the west pier, indicating that transport of beach or lake bottom material to this area is occurring. The organic content was higher in samples collected in the Vermilion River channel than it was in samples collected in the lake approach area.

The Buffalo District has also taken samples during July 1978, October - November 1979 and September 1981. The 1978 and 1979 samples were analyzed for grain size as well as organic content. In addition, the 1981 samples are being chemically analyzed for nutrients, heavy metals, selected pesticides, PCB's, oil and grease and other pollutants. The results of these sampling programs substantiated the results and conclusions of the Stanley analysis. Results of these Corps sampling programs are available from the Coastal Section of the Buffalo District upon request.

## BREAKWATER EFFECT ON SEDIMENT ACCUMULATION

To facilitate analysis of the study area, the project was divided into three sections: the Lagoons and River Channel; the River Entrance Channel; and the Lake Approach Channel.

### Effect of the Breakwater on Lagoons and River Channel

For the detached breakwater to affect sedimentation in the Vermilion River, the breakwater:

- would have to act as a blockade causing an increase in the river's depth with a proportionate decrease in its velocity, or

- would have to affect the type or amount of sediment that enters the river, or

- would have to reduce the cleanout character by reducing surge or some other natural phenomena.

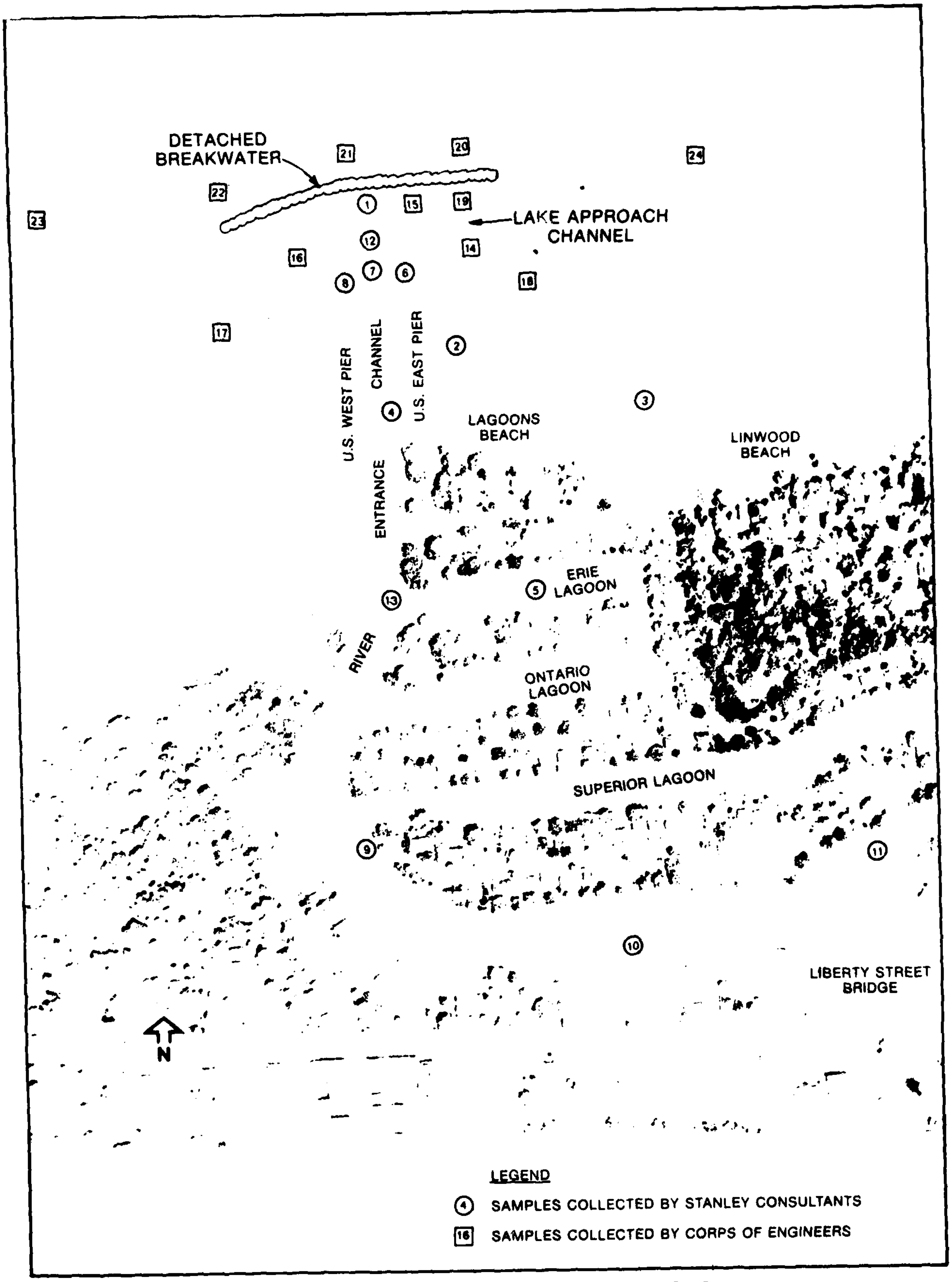



**Figure 23 • SEDIMENT SAMPLE LOCATIONS**

Table 16 - Material Classification of Sediment Samples (1)

| Sample Location | Material Classification | Organic Content (% Dry Weight) |
|---|---|---|
| 1 | Silt and clay | 1.1 |
| 2 | Fine sand | 0.5 |
| 3 | Fine sand | 0.5 |
| 4 | Fine sand, some gravel and some silt and clay | 0.7 |
| 5 | Silt and clay | 1.4 |
| 6 | Fine sand | 0.3 |
| 7 | Fine sand, silt and clay, leaves and twigs | 2.2 |
| 8 | Fine sand | 0.6 |
| 9 | Silt and clay, leaves | 2.0 |
| 10 | Silt and clay | 1.1 |
| 11 | Silt and clay | 1.5 |
| 12 | Silt and clay, some sand | 2.1 |
| 13 | Silt and clay | 1.8 |
| 14 | Silt and clay | N/A (2) |
| 15 | Silt and clay | N/A (2) |
| 16 | Silt and clay, trace sand | N/A (2) |
| 17 | Large stones | N/A (2) |
| 18 | Fine sand | N/A (2) |
| 19 | Silt and clay, trace sand | N/A (2) |
| 20 | Cobbles | N/A (2) |
| 21 | Hard bottom | N/A (2) |
| 22 | Medium sand | N/A (2) |
| 23 | Hard bottom | N/A (2) |
| 24 | Hard bottom | N/A (2) |

(1) Stanley Consultants Report, April 1978
(2) Not Analyzed (Corps of Engineers Samples)

a. <u>Effect on Velocity</u>

A HEC-2 computer model was used to determine river velocities with and without the breakwater. A flow of 500 cfs was chosen as low flow for the first set of computer runs. In order to check all cases, separate computer runs were made assuming a high lake level (574.3, IGLD), a low lake level (568.0), and an average lake level (570.4). Computer runs were also made assuming first that all flow from the river passed through the east lake approach channel and then as a separate run assuming that all flow passed through the west lake approach channel. Runs were made using the design channel depth and then separate runs were made assuming that a portion of the lake approach channel had silted in. The maximum change in computed river velocity due to the breakwater occurred at the lowest lake levels. Average river velocity at high and low lake levels and the change in river velocity at low lake levels caused by the breakwater are summarized in Table 17. The computer runs indicated that the detached breakwater has essentially no effect on the velocity on the river channel at a discharge of 500 cfs. At lower flow rates, the effect will also be negligible.

Computer runs for situations similar to those described above were also made assuming a flow of 1,000 cfs in the Vermilion River. Results of these computer runs indicate that the detached breakwater has essentially no effect on the velocity of the river at a discharge of 1,000 cfs (reduction in velocity of less than 0.001 ft/sec as shown in Table 17). A flow rate of 3,000 cfs was also selected for analysis. It should be noted that flow in the Vermilion River is less than 3,000 cfs, approximately 99 percent of the time. At a flow of 3,000 cfs, the velocity is approximately 2.0 fps, and the change caused by the detached breakwater is less than 0.01 fps and is considered insignificant.

A flow rate of 14,000 cfs was selected as the maximum rate because it is the amount of flow which the main channel of the river can carry at high levels without overtopping the piers. At this flow, the computer model indicates the velocity decrease in the river is less than 0.08 feet per second, also considered to be negligible.

Table 17 - Breakwater Effect on River Velocity (1)

| River Discharge (cfs) | Average Velocity High Lake Level (fps) | Average Velocity Low Lake Level (fps) | Maximum Reduction in Velocity Due to Breakwater* (fps) | Percent |
|---|---|---|---|---|
| 500 | 0.22 | 0.34 | <0.001 | <0.1 |
| 1,000 | 0.44 | 0.68 | <0.001 | <0.1 |
| 3,000 | 1.31 | 2.04 | 0.004 | 0.2 |
| 14,000 | 6.12 | 9.52 | 0.078 | 0.8 |

* occurs at low lake level

(1) Stanley Consultants Report; April 1978

b. Effect on Sediment Load

Sediment accumulation along both the east edge of the river entrance channel and the eastern lake approach have been the areas of greatest concern. The sediment along the east edge of the channel consists primarily of beach sand blown or washed over the east pier during northeasterly storms. With this possible exception, the offshore breakwater has no effect on the amount or type of sediment which enters the Vermilion River.

c. Effect on Cleanout

The offshore breakwater has reduced the surge effect which existed in the lagoons and river channel during storms prior to the construction of the breakwater. Cleanout phenomena is not affected since the surging which existed prior to construction of the breakwater did not result in velocities large enough to scour sediment from the bottom of lagoons. Also, this type of surging would not result in a net flow through the area capable of removing significant quantities of sediment even if it were scoured into suspension.

d. Conclusions

With the breakwater acting as a restriction, there is no depth change in the river since the related decrease in river activity is negligible.

The offshore breakwater has no effect on the type or amount of sediment which enters the Vermilion River.

There is no known natural phenomena which existed either before or after construction of the offshore breakwater which affects the rate of sediment accumulation in the lagoons or the river channel.

Effect of the Breakwater on River Entrance and Lake Approach Channels

Since construction of the breakwater in 1973, dredging of the river entrance channel and lake approach channel has been performed on a number of occasions (see Table 15, preceeding). Between 1935 and 1973, no dredging was performed except in 1969 when a large shoal was removed from the channel entrance following the July 1969 flood. This indicates that the breakwater has undoubtedly contributed to the amount of sedimentation in these areas although increased shoreline erosion during the recent high lake level period is partially causative.

The lake approach channels were constructed as part of the detached breakwater project. The sediment deposits which have occurred in the channels consist of both clay and silt sized paricles and some pockets of silty sand. The clay and silt content indicates that some of this sediment is carried in the Vermilion River. The sand is presently primarily near the pier ends at the river entrance, and is probably transported into this area by lake wave action and associated littoral currents. A majority of the silt and clay particles from the Vermilion River which settle in the lake approach channels behind the breakwater would most likely be carried northerly to the

deeper part of the lake if the breakwater were not in existence. In addition, the dredging activity makes the approach channels lower than the natural area thereby tending to trap the sediment. It therefore appears that the breakwater is at least partially responsible for sediment deposition in the lake approach channels. However, maintenance dredging is performed, as required, to maintain authorized project depths in Vermilion Harbor.

CONCLUSIONS

The natural backwater effect of Lake Erie enhances sedimentation in both the river and lagoon area by reducing the hydraulic gradient and slowing the velocity of the river. In the period following construction of the breakwater, scouring action during periods of high discharge has kept the main (center) channel close to project depths. Bends in the river, however, have shifted somewhat by eroding on one side of the river, with sediment buildup on the other. This is caused by natural processes and is not influenced by the breakwater.

Since the breakwater has no significant effect the flow velocity in the Vermilion River, it has no effect on the rate of sediment accumulation in the lagoons or river channel. Therefore, mitigation of sediment accumulation in the lagoons and river channel is not required. However, it appears that the offshore breakwater does cause some sedimentation in the lake approach channels and may possibly increase the rate of sediment accumulation along the edge of the river entrance channel near the east pier. Since mitigation of this effect is already provided in the form of periodic maintenance dredging, it is concluded that no further action is necessary for mitigation of additional harbor sedimentation caused by the detached breakwater.

# NAVIGATION

## INTRODUCTION

The purpose of this study was to analyze the impacts of the recently constructed offshore breakwater on navigation safety in Vermilion Harbor. Analysis of these impacts will include consideration of the protection afforded against wave action, the change in traffic patterns and changes in the visual conditions at the harbor mouth. Problem areas, identified through analysis of harbor conditions and survey of boater opinions, will be described with respect to safe boat navigation at Vermilion.

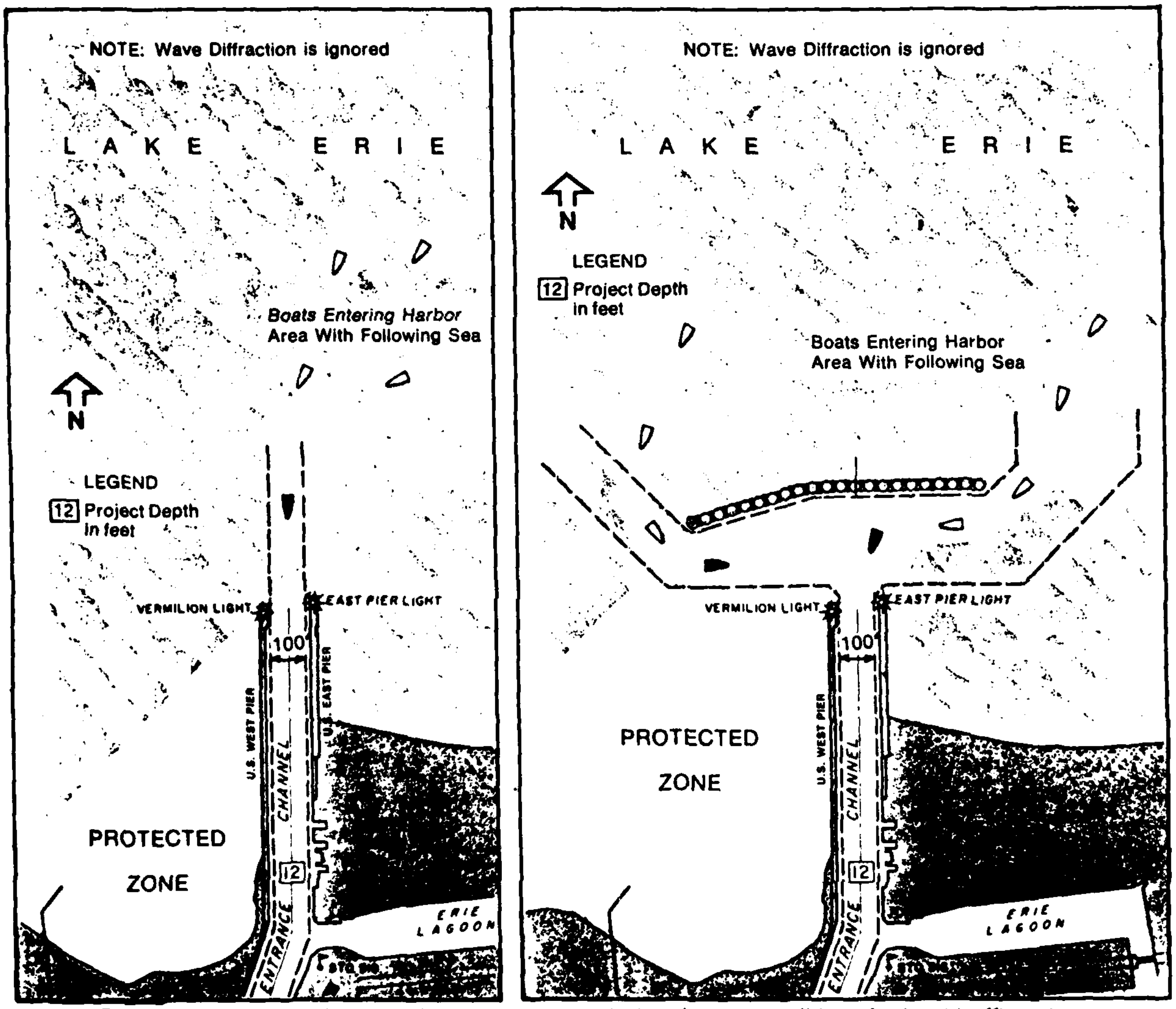
Navigation factors important for safe operation of all craft using the entrance of Vermilion Harbor include:

- Harbor Configuration - the location and dimensions of channels, piers, breakwater, and lights.
- Channel depth as related to vessel draft.
- Traffic congestion related to numbers of other vessels entering and leaving the harbor; especially during storms.

## TRAFFIC PATTERNS AND CONGESTION

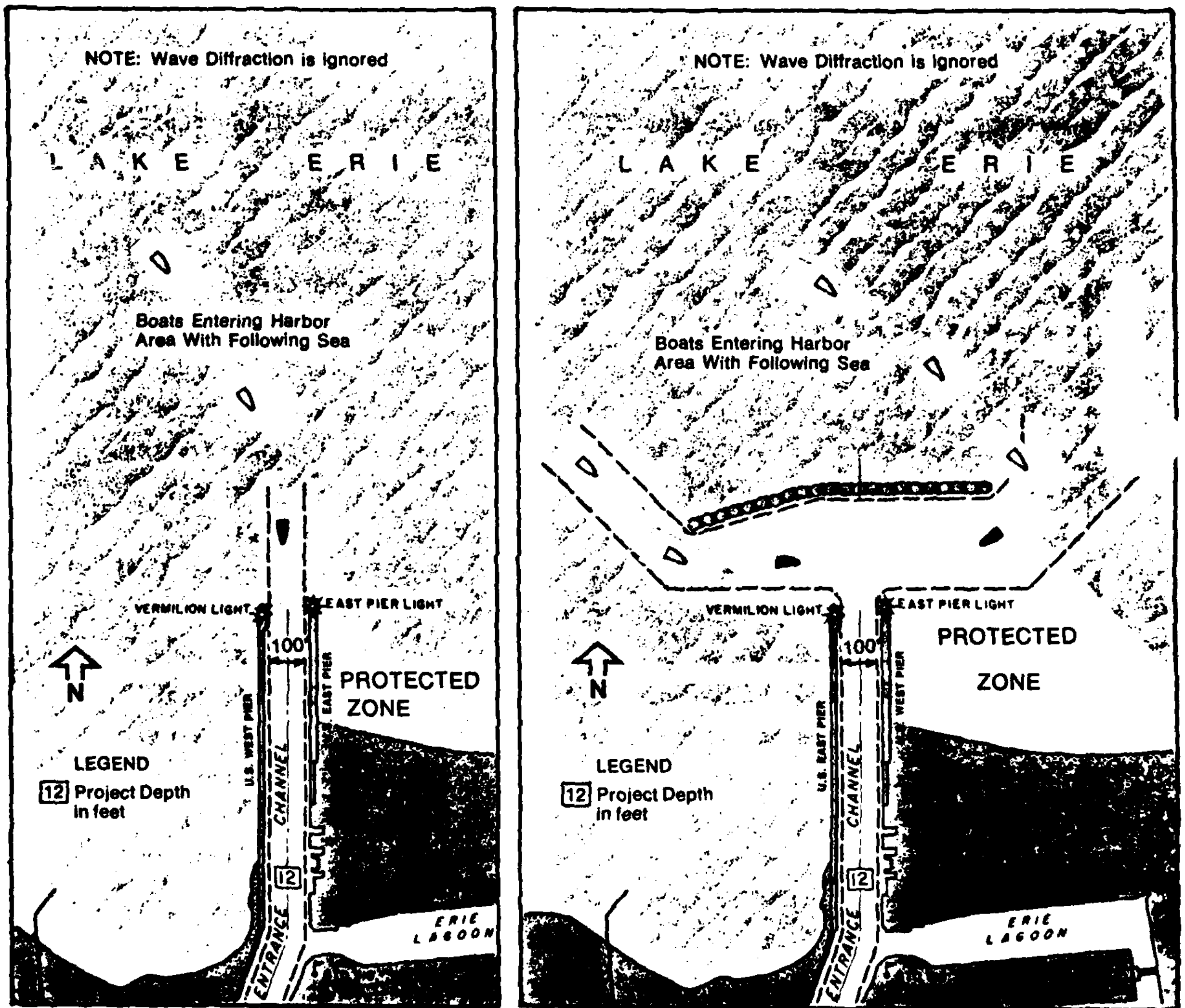
The detached breakwater was constructed to provide a zone of calm water in which to maneuver into and out of the entrance channels. The location and extent of the zone protected from northeast and northwest waves before and after breakwater construction is shown on Figures 24 and 25, respectively. Before breakwater construction, boats could only approach the unprotected river channel 'straight-in'. When seas were following (or quartering) significant power was necessary to maintain sufficient speed to allow controlled steering of a boat. This condition could prove hazardous to an inexperienced boat operator, particularly one with an underpowered boat. After construction of the breakwater, a zone protected from waves was created of sufficient size and configuration to permit vessels approaching the river mouth to enter the channel from the open lake at either end of the breakwater. An operator can now always bring his boat into the harbor without encountering following seas by choosing the appropriate lake approach channel. This results in safer boating operation.

Boats entering and leaving the harbor are governed by Rules of the Road (RR), as published in U. S. Coast Guard Document 172. In accord with RR, vessels operating in calm to moderate wind and sea conditions (wind 0 to 16 knots) should enter the harbor using the west lake approach channel.




Protected zone at harbor mouth with northeast wind and wave conditions for boat traffic entering harbor before and after breakwater construction.

**Figure 24 • PROTECTED ZONE WITH NORTHEAST WIND**




Protected zone at harbor mouth with northwest wind and wave conditions for boat traffic entering harbor before and after breakwater construction.

**Figure 25 • PROTECTED ZONE WITH NORTHWEST WIND**

Departures should likewise be accomplished using the east lake approach channel.

In actual practice, boaters do not always follow the prescribed procedures, but rather enter the harbor by the most convenient route given the prevailing wind and wave conditions. The result is that boats may enter the harbor from both lake approach channels during peak hours, and the protected area inside the breakwater can become congested.

This is particularly a problem when sudden squalls force a large number of boats to seek shelter quickly. Several boaters have reported difficulty in entering the channel due to this congestion, with as many as 25 boats laid up inside the breakwater.

Congestion in the harbor mouth is normally of short duration and occurs during periods of peak harbor usage. Harbor traffic is at a peak during weekend or holiday afternoons with warm, sunny weather. Figure 26 shows the general increase in boat registrations in the area, and it is likely that the harbor areas would be more congested now even if the breakwater had not been built. The congestion in the area between the pier ends and the breakwater has occurred only since construction of the wall. Prior to construction, boats were forced to line up in the open lake when entering the harbor, and channel congestion was minimized except under storm conditions.

In summary, congestion of the river channel has always been somewhat of a problem, and is related to boat use, not the breakwater. The area between the breakwater and piers is now congested on occasion, whereas the traffic previously distributed itself throughout the general lake vicinity. However, this congestion occurs in calm water, whereas, the breakwaater it occurred in before, was in rough water conditions. There are no reports of accidents due to this congestion, and local boaters do not feel a significant hazard has been created.

## RESTRICTED VISIBILITY AND BLIND CORNERS

Safe navigation at Vermilion Harbor depends a great deal on the ability of each skipper to see other boats in time to minimize risk of collision. Several aspects affecting visibility include:

- Height of eye above water for each skipper.

- Lake level in relation to the top elevation of piers and breakwater.

- Limited visibility zones within the harbor approach area.

These factors may result in the creation of certain navigation hazards related to limited visibility. An example of this would be a blind corner, where a boat would not be able to see another boat because of an obstruction between them (see Figures 27 and 28).

Height of eye above the water surface varies with the type of boat from small, open boats to large cruisers with flying bridge configuration. At

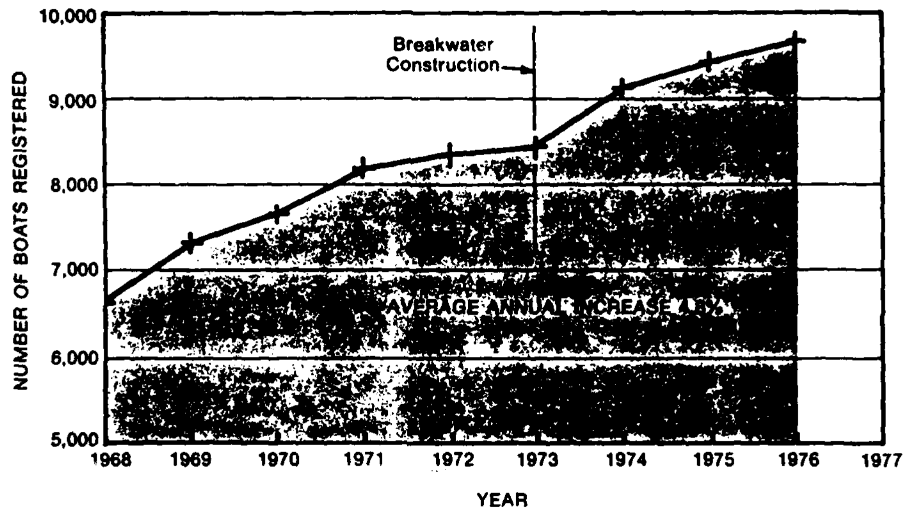
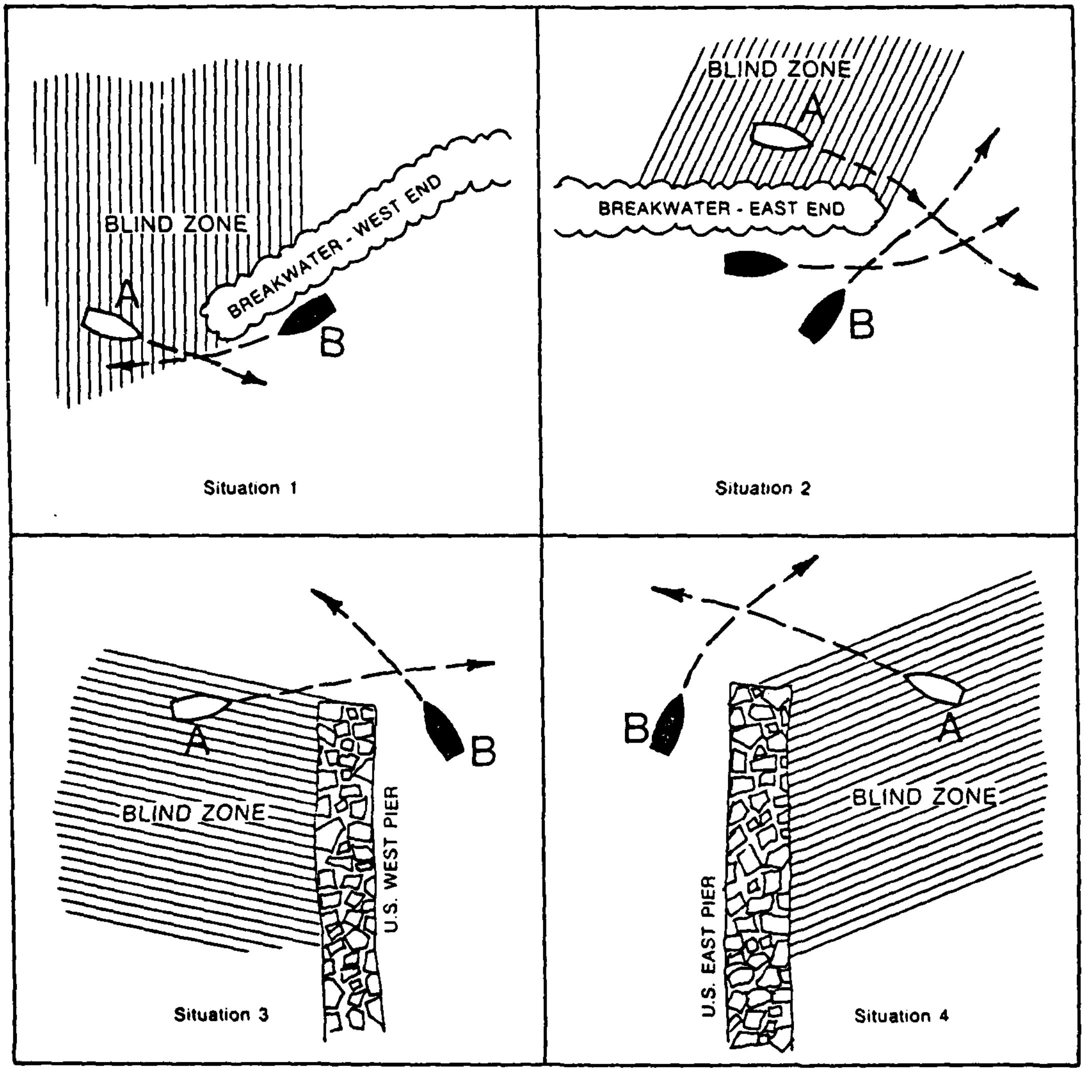



**Figure 26 • NUMBER OF BOATS REGISTERED IN ERIE & LORAIN COS., OHIO**




Blind zone hazard situations where vessel "A" is in the blind zone of vessel "B".

**Figure 27 • BLIND ZONE HAZARD SITUATIONS**

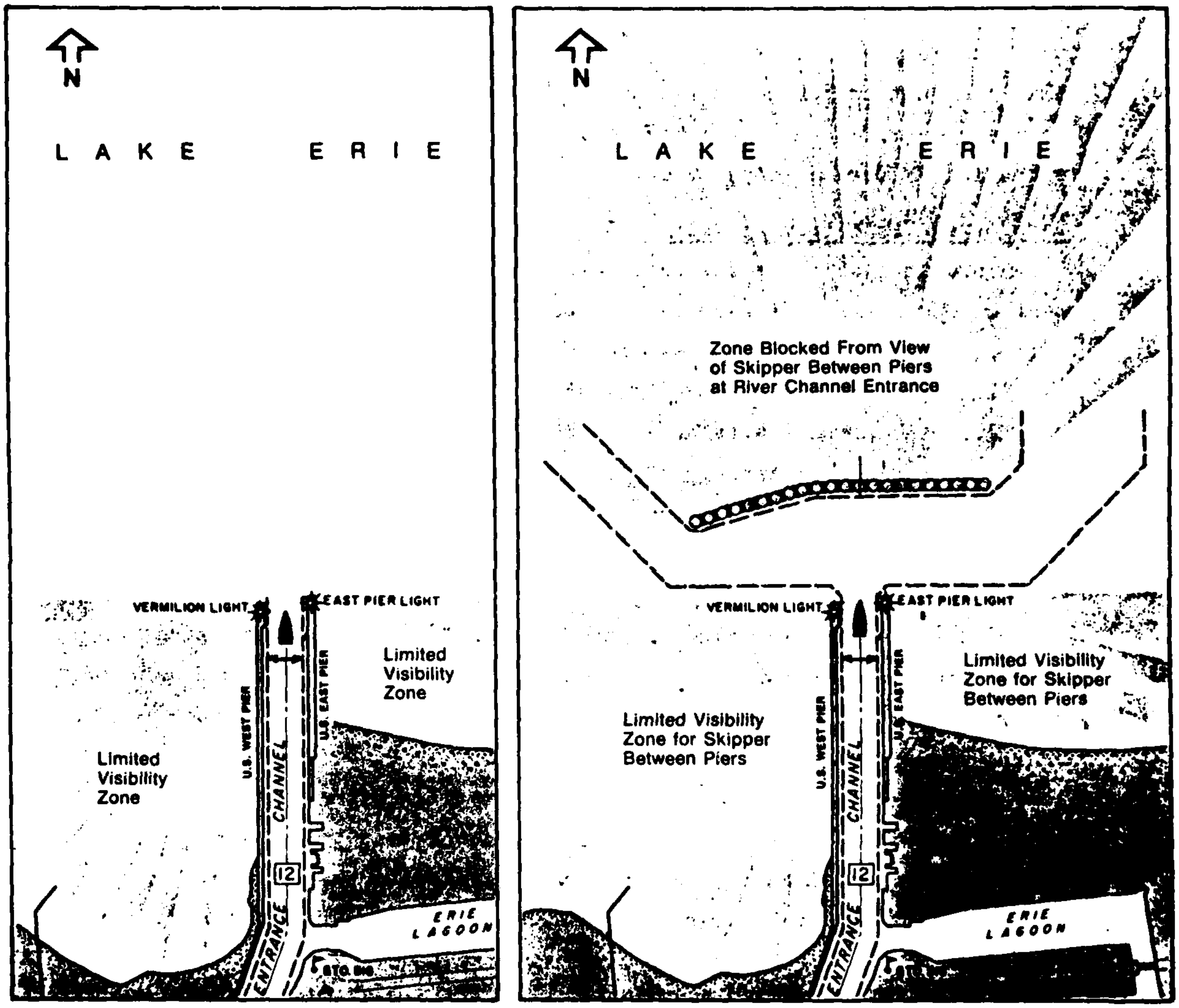



**Figure 28 • LIMITED VISIBILITY ZONES**

Vermilion, the predominant number of boats are small to medium size with corresponding eye height above water from 3 to 8 feet. Commercial fishing and large cruising boats have more visibility.

Harbor structures protruding above the lake surface can block visibility depending on lake levels and height of eye. The top of breakwater is 10 feet and the piers extend 6.5 feet above LWD. During periods of high lake levels, such as in 1973, the tops of breakwater and piers would be 7.0 and 3.5 feet above the water surface, respectively. It can be seen that changes in lake levels result in definite changes in the way harbor structures block visibility from harbor craft.

Potentially hazardous situations in which restricted visibility is a major factor have been identified through field survey observation and analysis. Vessels operating in the lake approach channels near the entrance piers are depicted on Figure 27. These four areas each represent situations in which a 'blind' corner or zone is present for some types of boats, depending on the existing lake level. The situations at each end of the offshore breakwater are the most hazardous, due to the higher elevation of the breakwater. This zone is also in the area of greater traffic density. At the pier ends, depicted in situations 3 and 4 on Figure 27, a blind zone is only created for the smaller boats, and only when lake levels are low. Situations 3 and 4 on Figure 28 existed prior to construction of the breakwater. Lake boaters are also aware of the possibility of other vessels emerging from the harbor mouth, and, therefore, do not often use the southern edge of the east and west approach channels. These situations have not been affected by the offshore breakwater.

Contact with local boaters indicated that people are aware of the areas of limited visibility and do not feel that these areas create a significant hazard.

## BREAKWATER RELATED ACCIDENTS

Navigation hazards causing accidents were investigated by a search of available records as well as interviews of the Government agencies responsible for compiling accident reports and data.

Available records include direct contact with responsible agencies as well as information contained in the U. S. Corps of Engineers Survey Report and Environmental Statements prepared for breakwater construction and maintenance operations. Before breakwater construction several accidents were reported, many of which were cases of tugs foundering off Vermilion. The breakwater was completed in 1973.

Since construction of the breakwater, there have been two accidents reported involving the breakwater. A minor accident occurred in late July 1977. A large cabin cruiser hit the breakwater on the north side near the west end. The accident occurred at night, and it was reported that the west light was not operating. A major accident occurred 18 October 1980. This accident involved a drowning of one of the passengers. A 19-1/2 foot

inboard-outboard open motorboat struck the north side of the breakwater approximately 100 yards east of the east entrance channel. All aids to navigation were burning properly; neither the aids to navigation nor the breakwater were contributing causes to the accident.

Other undocumented accidents resulting in moderate property damage have been described by local boaters.

Agencies of Government responsible for investigating and reporting boat accidents include: Vermilion Police Department, Ohio Division of Watercraft, and the U. S. Coast Guard. There are no records showing boat accidents, damages, or injuries at Vermilion Harbor in the files of the Ohio Division of Watercraft or the U. S. Coast Guard, 9th District, Office of Boating Safety at Cleveland. The local law enforcement agency with harbor responsibility is the Marine Officer of the Vermilion Police Department.

Navigation safety for harbors on Lake Erie is the responsibility of the U. S. Coast Guard, 9th District, Aids to Navigation Office in cooperation with the local Port Authority. Citizen complaints and related investigation would be conducted by the office. There is no record of complaints on file for Vermilion Harbor and no know correspondence regarding the subject.

In summary, since the construction of the breakwater, there have been two reported accidents involving the breakwater; however, the breakwater is not a contributing factor in these two accidents. The possibility exists that more accidents occurred but were not reported.

## CONCLUSIONS

### Stanley Consultants Study

The analysis included an evaluation of the beneficial and adverse effects the breakwater has had on small-boat navigation at Vermilion Harbor. The purpose of the breakwater is to reduce surging in the harbor and to provide an area sheltered from high waves. The investigation showed that a zone of congestion between the breakwater and piers has been created by the breakwater, and zones of limited visibility do exist at the ends of the breakwater. However, a survey of local boaters showed that the majority feel the beneficial aspects of surge and wave reduction provided by the breakwater outweighs the inconvenience associated with occasional congestion and the need for increased caution in the vicinity of the breakwater. In view of these comments, it was concluded that no significant hazards to navigation have been created by the 1973-1974 harbor improvements.

### District's Evaluation and Conclusions

Since the breakwater does reduce wave and surge action in Vermilion Harbor, and since it is the view of most of the local boating community that this aspect outweighs the periodic inconveniences and need for caution, the District concluded that the occasional inconvenience to recreational boaters does not warrant further consideration. No further analysis was made of this impact.

# AESTHETIC'S

CRITERIA

The term aesthetics has been defined as "a particular philosophical theory or conception of beauty." Like beauty, then, the word has no clear and agreed-on definition.

Aesthetic values are attributed to man's sensory perception of the environment, including tangible and intangible qualities. However, aesthetic values and attitudes are also related to the political, cultural, and economic phenomena of the period and are further influenced by conditions of the physical environment and the way these factors satisfy man's needs. Such values are not generally expressed as standards (as is the purity of water or the amount of pollution allowable in the air) but remain an illusive and subjective value of the individual.

The measure of aesthetic effect caused by the breakwater must be based on a determined level of quality or perception that existed prior to construction. The difference between present and preconstruction conditions should indicate the effect related to breakwater, all other factors remaining equal.

The effect of the detached breakwater was evaluated based on the 13 aesthetic elements listed below:

1. Harbor Entrance Scenic Quality.

2. Picturesque Composition.

3. Visual Interest.

4. Topographic Complexity.

5. Shoreline Complexity.

6. Public Accessibility.

7. Structural Mass Compatibility.

8. Construction Material.

9. Color Compatibility.

10. Overall Design Form/Function.

11. Materials Textural Compatibility.

12. Level of Overall Conditions and Maintenance.

13. Related Environmental Conditions as Related to Aesthetics.

## LOCAL INTEREST

The importance of local interest as an indicator of effects was considered by analysis of complaints delivered to the Corps office in Buffalo, and informal interviews with city officials and citizens. Since the nature of aesthetics is subjective and not given to precise measurement, the validity of balloting or quantitative surveying the population for, "yes it is" or "no it is not" (aesthetic), were not considered to be useful mechanisms. Interviews were conducted, however, to determine feelings toward the aesthetic qualities of the breakwater. General questions were asked regarding impressions or complaints about the structure from an aesthetic standpoint.

The most visible aesthetic sentiment expressed to date has been in those letters received by the Buffalo District in conjunction with other statements of complaints regarding such possible breakwater effects as shore erosion, beach pollution, water supply pollution, navigation hazard, and channel sedimentation. Yet, although more than 50 individuals have written letters to the Corps regarding the breakwater from 1974 to 1977, very few comments deal directly with the question of aesthetic effects. The significance of aesthetic effects inferred by correspondence received to date is secondary in relation to other items of concern.

Direct contact with boat owners and local people during this study has failed to indicate specific objections to the breakwater on aesthetic grounds. The majority of the people seem to feel that the beneficial aspects of reduction in waves and surge action outweigh the inconvenience associated with occasional congestion and increased caution in the vicinity of the breakwater.

## EVALUATION

Thirteen aesthetic elements were identified to evaluate conditions at Vermilion Harbor before and after construction of the breakwater, as mentioned in the subsection titled "Criteria."

The list of elements was derived from surveys of shoreline and related harbor structures referenced in this report. Specific elements were selected, or added, on the basis of their relevance to conditions at Vermilion Harbor, the breakwater setting and design characteristics of the structure. A summary rating of aesthetic elements with relative indication of low, moderate, or high significance is given in Table 18.

Photographs of the harbor setting and breakwater were used to provide a visual vocabulary for describing the project. Individual photographs are numbered for reference in the text and include a caption statement of their

Table 18 - Relative Rating of Aeshtetic Elements Before and After Breakwater Construction at Vermilion Harbor (1)

| Number | Aesthetic Element | Rating Before | Rating After | Comment |
|---|---|---|---|---|
| 1 | Harbor entrance scenic quality | Moderate | Moderate | |
| 2 | Picturesque composition | Low | Low | |
| 3 | Visual interest | | | |
| | Foreground | Low | Low | |
| | Middleground | Low | Low | |
| | Background | Low | Moderate | Distant view from public and private shore point - slight increase |
| 4 | Topographic complexity | Low | Low | |
| 5 | Shoreline complexity | Low | Low | |
| 6 | Public accessibility | | | |
| | Water side | Moderate | Moderate | |
| | Shore side | Low | Low | None before or after |
| 7 | Structural mass compatibility | Moderate | Low | New structure is in contrast to piers |
| 8 | Construction material compatibility | Moderate | Low | Formal steel vs. informal rock |
| 9 | Color compatibility | Moderate | Low | Rusty steel-industrial vs. light earth tones of rock |
| 10 | Overall design form/function | Low | Moderate | Functional |
| 11 | Materials textural compatibility | Moderate | Low | Human scale or rock vs. monolithic, huge new structure |
| 12 | Level of overall condition and maintenance | | | |
| | Piers | Moderate | Moderate | |
| | Breakwater | N/A | High | New construction contrast by design and material with much older and different pier condition |
| 13 | Related environmental phenomena | Moderate | Moderate | |

(1) Stanley Consultants, April, 1978

relation to aesthetic elements. An index map showing location and direction of the photographs is shown on Figure 29.

The following paragraphs summarize the field observations related to the aesthetic elements.

1. Harbor Entrance Scenic Quality

The harbor entrance and river channel mouth are not prominent features from the land side due to the remoteness and isolation from points of public access. From the public beach at the foot of Main Street to the center of the new breakwater is nearly 1,500 feet (Photograph 15). Scenic impact from within the protected zone (Photographs 18, 19, 20) is directly related to the breakwater and its effect of blocking lake views entirely. In summary, the scenic attraction of the harbor entrance is not affected by the breakwater.

2. Picturesque Composition

The long, low, dark form lies motionless against the light background of Lake Erie and sky. At a distance, it resembles a partially submerged ore boat in sharp contrast to the natural forms of adjacent wooded shoreline, beach contours or the waves (Photographs 13 through 17).

3. Visual Interest

The breakwater's charm is far from interesting. Visually, interest from the land side is severely limited because of the lack of public accessibility to the harbor entrance piers. The prime visual interest is for boats entering and leaving the protected harbor zone (Photograph 20) because of the free access for boaters on all sides of the structure (Photographs 13 through 17). Visual interest in the structure is therefore minimal.

4. Topographic Complexity

Proximity of the breakwater to a shoreline of contrasting elevation or ruggedness, accompanied with a high degree of public accessibility, would add to the aesthetic impact of the structure. The Vermilion Harbor entrance, however, provides virtually no topographic relief or rugged landscape, and the nearest slight bluff and public vantage point is at the north end of Washington Street (Photographs 13 and 17). Topographic diversity of the site is of minimal significance for purposes of aesthetic assessment.

5. Shoreline Complexity

The degree of shoreline complexity was considered as a factor for examination in the course of field analysis. A site near a shoreline that includes bays, islands, peninsulas or spits would offer contrasting land forms and greater diversity than the relatively plain setting at Vermilion. Shoreline complexity has little significance in rating aesthetic effects at Vermilion Harbor (Photograph 17).

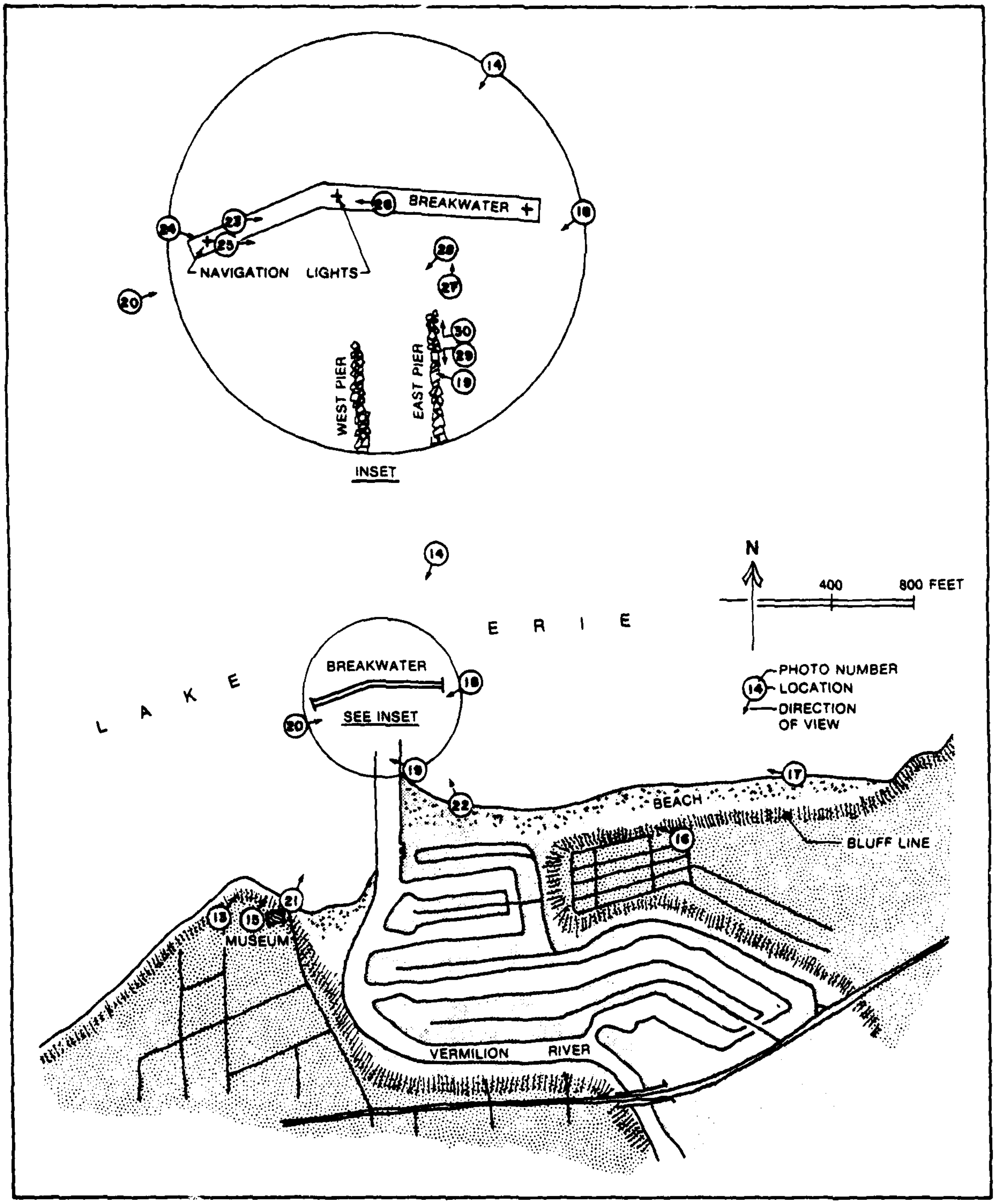
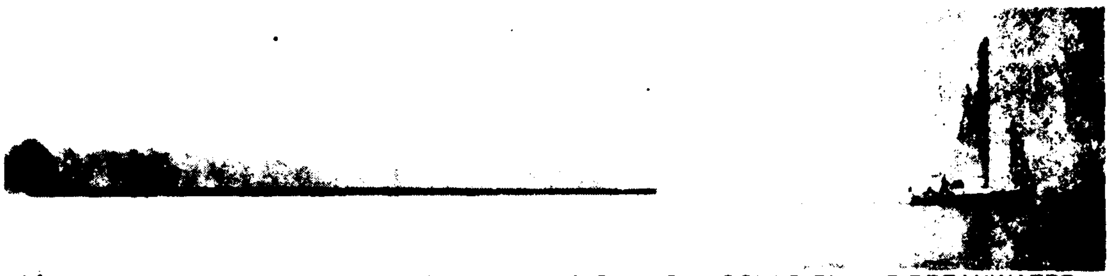
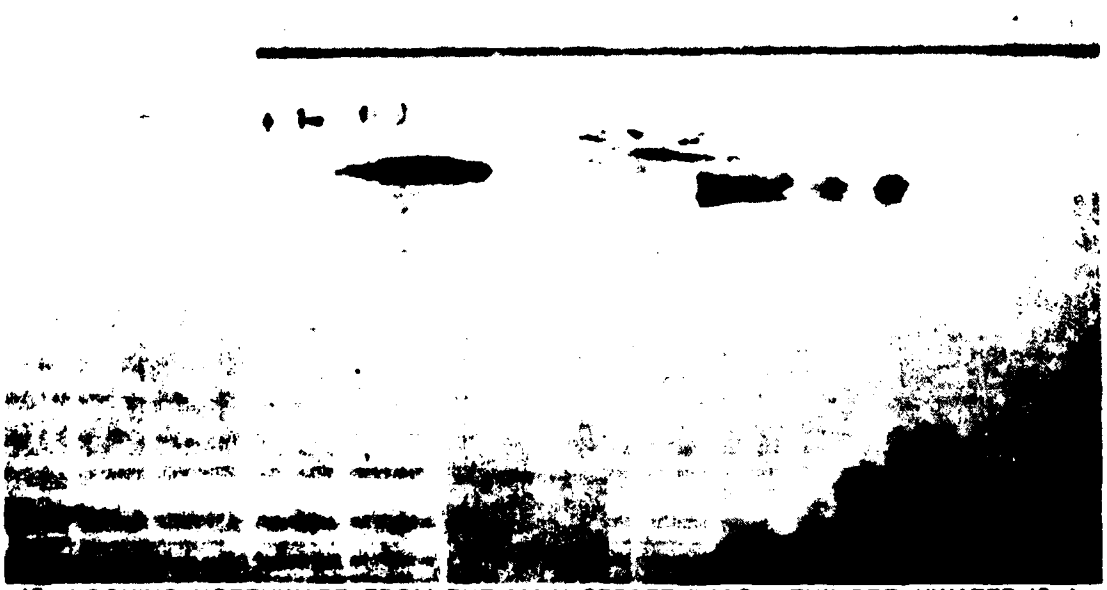



Figure 29 • PHOTOGRAPH INDEX MAP

13 • LOOKING EAST FROM THE BLUFF AT NORTH END OF WASHINGTON STREET. BREAKWATER IS A BACKGROUND ELEMENT OF VISUAL INTEREST OR LOW SCENIC QUALITY.



14 • HARBOR ENTRANCE VIEW FROM THE LAKE SIDE IS BLOCKED BY THE BREAKWATER. LOW TOPOGRAPHIC RELIEF IS INDICATED BY SHORE/TREELINE IN BACKGROUND.

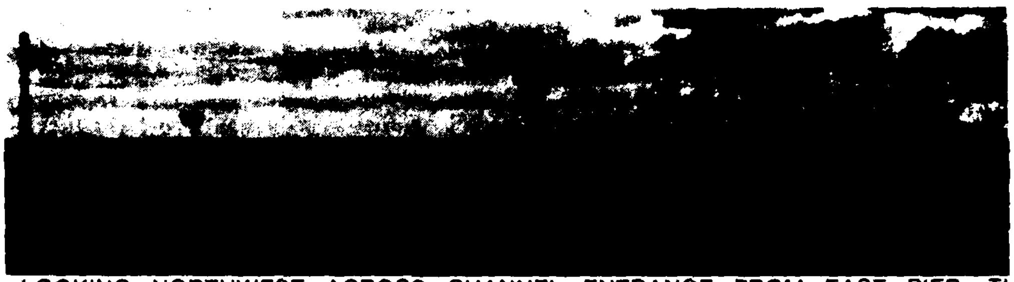


15 • LOOKING NORTHWARD FROM THE MAIN STREET BEACH. THE BREAKWATER IS A BACKGROUND ELEMENT OF VISUAL INTEREST AND PICTURE COMPOSITION.

16 • VIEW FROM THE BLUFF NEAR STEPS AT LINWOOD BEACH. THE BREAKWATER IS A BACKGROUND ELEMENT OF VISUAL INTEREST.

17 • LOOKING WEST FROM THE BEACH EAST OF THE HARBOR ENTRANCE. LOW TOPOGRAPHIC RELIEF INDICATED BY THE LONG, LOW, HORIZONTAL PROFILE OF PIERS AND NEW BREAKWATER AT THE RIVER MOUTH.

18 • HARBOR APPROACH CHANNEL VIEW FROM EAST END OF BREAKWATER. SHOWING CONTRAST OF FORM, MATERIALS.



19 • LOOKING NORTHWEST ACROSS CHANNEL ENTRANCE FROM EAST PIER. THE FUNCTIONAL FORM & CONTRASTING LEVEL OF MAINTENANCE FOR OLD AND NEW CONSTRUCTION IS EVIDENT.

20 • VIEW INCLUDING WEST END OF BREAKWATER. SHOWING CLEAN FUNCTIONAL LINES OF CONSTRUCTION. PICTURESQUE COMPOSITION FROM WATER SIDE IS POSSIBLE WHEN AIDED BY REFLECTION FROM GLASSY WATER.

6. Public Accessibility

Public awareness of both the breakwater and its aesthetic impact is related to the breakwater's physical and visual accessibility. Easy access by the public permits a greater awareness, while a situation remote from physical and visual access is more likely to receive less attention.

Public access to the piers is blocked by private property, although free access is readily available from the water side. Visual access is possible from Main Street Beach as well as several private residences. As viewed from the land side, the breakwater is generally seen as a background object of minimal visual significance. Overall public access to the breakwater is limited to visual contact and then only as a distant view.

7. Structural Mass Compatibility

Structures in the harbor and adjacent shore combine with the shallow draft to form a distinctly recreational small craft harbor atmosphere in contrast to the industrial port facilities at Lorain and Cleveland. The large mass of the new breakwater is shown in Photographs 19, 20, 23, 26, 27 and 30. The new structural mass of the breakwater contrasts with the older piers, as shown in Photographs 27, 28, and 29.

8. Construction Material Compatibility

The most visually apparent construction materials for each harbor structure determine its visual character. The east and west piers are capped with rectangular sandstone blocks while the breakwater is a series of steel sheet pile cells capped with a slab of concrete (Photographs 18, 23, 26). The steel sheet is rust finished, while the three navigation light support posts are gray galvanized iron (Photographs 24 and 26).

The materials of the breakwater visually contrast with the parallel piers with the contrast heightened by both the dominant position and relative size of the breakwater when compared to the piers.

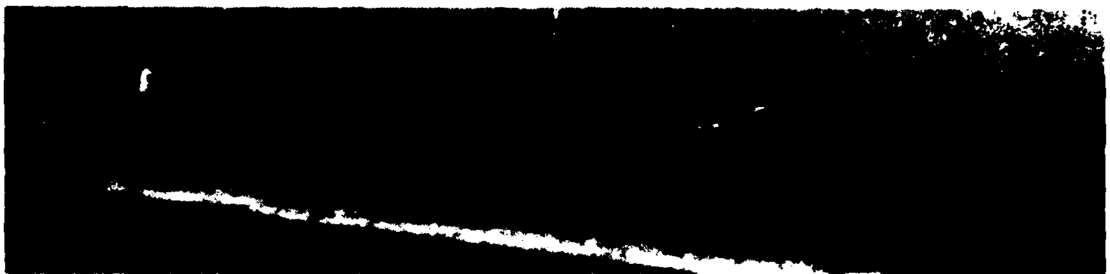
9. Color Compatibility

Established colors for the Vermilion Harbor area are derived from structural stone of the east and west piers and from the sand and gravel materials of the beaches east and west of the entrance channel. Predominating colors are earth browns, vermilion (from which the area derived its name), and slate blues and grays. The breakwater's color is rusty steel which contrasts with the natural colors of the piers and beaches.

10. Overall Design Form/Function

The parallel piers forming an entrance to Vermilion Harbor were initially constructed to maintain a sand-free channel through a sandbar at the river mouth, as well as to provide a safer entrance free from breaking waves. Public access was not provided; therefore, public use other than recreational boating cannot be considered a function of the piers at this time.

21 • NAUTICAL VIEW OF BREAKWATER FROM DISPLAY "BRIDGE" OF THE GREAT LAKES MUSEUM. A LOW LEVEL OF VISUAL INTEREST FOR BACKGROUND PICTORIAL COMPOSITION.

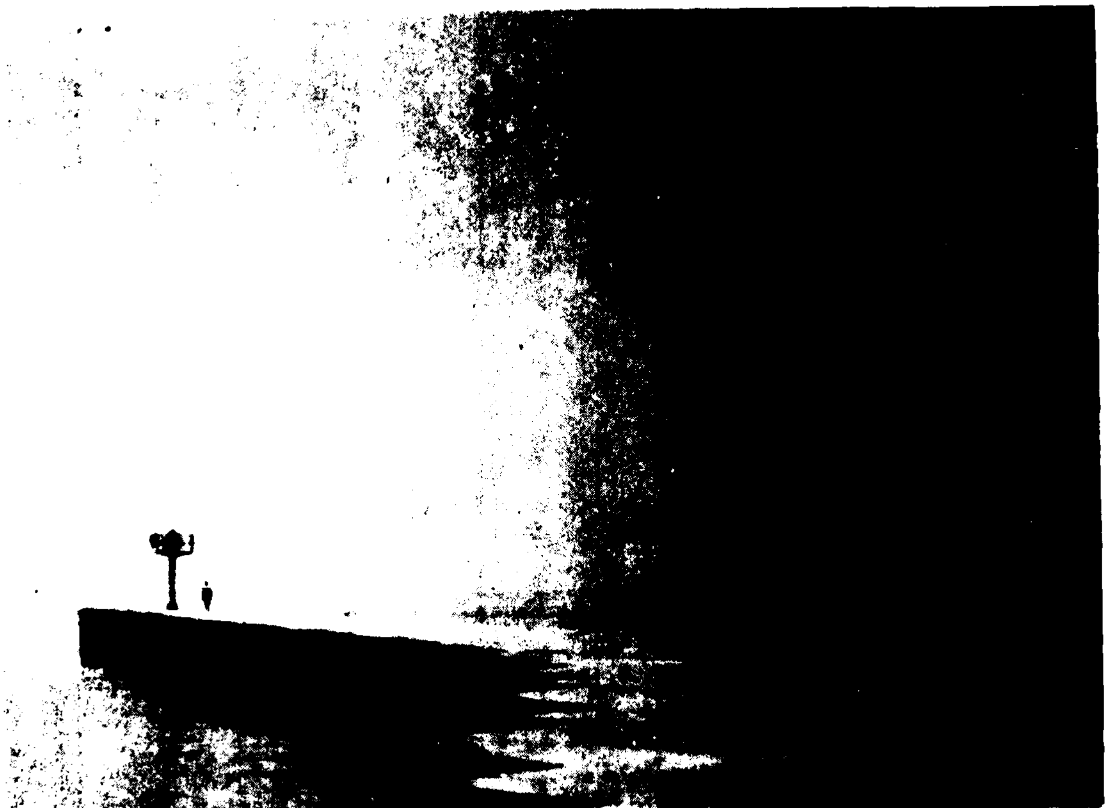


22 • VIEW NORTHWEST FROM BEACH EAST OF EAST PIER SHOWS LARGE SIZE OF BREAKWATER COMPARED TO EXISTING PIER AND SMALL BOAT.

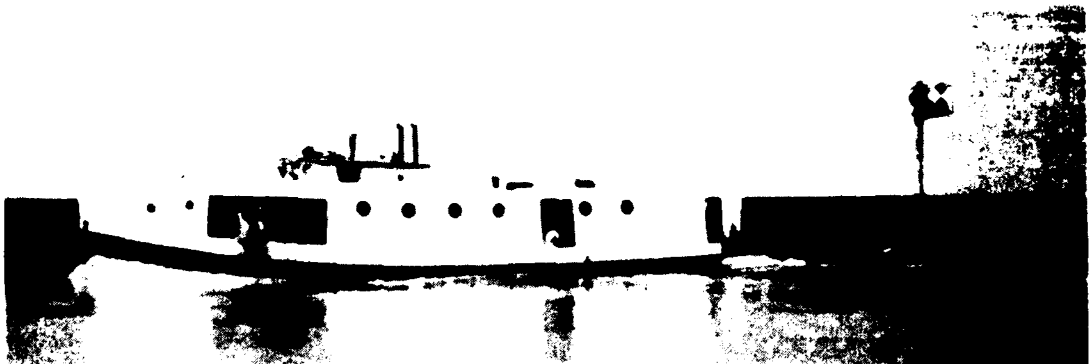
23 • VIEW LOOKING EAST ALONG LAKE SIDE OF BREAKWATER SHOWS MACHINE-LIKE GEOMETRY OF INTERLOCKING ARCS OF SHEET PILING. HUMAN FIGURE (SEE ARROW) INDICATES LARGE SCALE OF BREAKWATER.

24 • SUPPORT POST FOR NAVIGATION MARKER AT WEST END OF BREAKWATER IS SIMPLE & FUNCTIONAL WITH NO VISUAL ENHANCEMENT.

25 • MOORING CLEAT AND ACCESS LADDER FACILITATE FUNCTIONAL ACCESS FOR MAINTENANCE OR EMERGENCY.



26 • LOOKING WEST FROM CENTER OF BREAKWATER. HUMAN FIGURE INDICATES SCALE OF STRUCTURE. CONCRETE SURFACE AND FUNCTIONAL DESIGN FOR ABOVE WATER PORTION CONTRAST WITH NATURAL MATERIALS OF EXISTING PIERS.



27 • LOOKING NORTH FROM EAST PIER. FISHING TUG INDICATES LARGE SCALE OF STEEL BREAKWATER IN BACKGROUND.

28 • LOOKING SOUTHWEST ACROSS ENTRANCE CHANNEL BETWEEN PIERS. QUARRIED STONE GIVES SMALL SCALE, INCREASED VISUAL INTEREST, TEXTURAL PATTERN, AND NATURAL, WEATHERED APPEARANCE TO HARBOR ENTRANCE ZONE. CONTRAST WITH NEW BREAKWATER APPEARANCE IN PHOTO 15 ABOVE.

29 • EAST PIER LOOKING TOWARD SHORE AND UP THE RIVER CHANNEL TO RIGHT OF CENTER. RANDOMLY PLACED, IRREGULAR SIZE OF INDIVIDUAL STONES GIVE AN INFORMAL APPEARANCE TO PARALLEL PIERS.

30 • EAST PIER AND EAST END OF BREAKWATER. CONSTRUCTION MATERIALS CONTRAST QUARRIED STONE WITH STEEL SHEET PILING. SCALE OF MATERIAL MODULES IS EVIDENT WHEN RELATED TO HUMAN FIGURE IN PHOTO.

The new detached breakwater was designed as a single purpose structure to provide an adequate harbor-of-refuge for small craft cruising on Lake Erie and reduce hazards to vessels in the harbor entrance. Breakwater length, width, height, and materials were designed as the most economical solution to the harbor protection problem identified by local interest (see photographs 19, 20, 23). The design form is a harbor protection device with minimal flashiness. As such, it is an appropriate fit for a shallow draft, small craft recreational harbor.

11. Materials Textural Compatibility

The physical texture of materials is perceived by observers relative to their distance form the breakwater. Texture is related to overall design, module of construction, and the nature of material. Established texture of the parallel piers is related directly to the stone materials, their size, and the light-dark patterns created by shadows between the broken stone (Photographs 29, 30). The breakwater is constructed of a uniformly machined steel sheet piling with no modular light-dark pattern similar to that of the quarried stone (Photographs 27 and 28).

12. Level of Overall Maintenance and Condition

The overall condition and maintenance of the harbor entrance was judged by the appearance of the parallel piers and the breakwater. The appearance of the parallel piers is generally coarse and natural, owing in part to the material and manner of construction (Photographs 29 and 30). Age and weathering have also contributed to overall appearance (Photographs 19 and 28). The breakwater has the appearance of a machined object built from manufactured materials, with neat, crisp mechanical lines (Photographs 20, 23, 26). The new structure appears more formal and geometric than the older, more naturally appearing piers.

13. Related Environmental Phenomena

The construction of the breakwater has changed certain environmental conditions at the harbor entrance. Wave and surge action have been reduced and water currents have been altered to some extent. Harbor usage during fresh weather conditions may have increased, although specific information is not available to substantiate this. This increase is not believed to have resulted in a significant change in the aesthetic quality in the harbor area. Several other effects have been alleged by local citizens, as detailed in this report. Effects on these items have some impact on the aesthetic appearance of the area.

CONCLUSIONS

Based on field observations and interviews with boaters and residents, it is concluded that the general feeling of those interviewed is that the breakwater was designed as a functional structure. It is typical of marine protective works, being neither beautiful nor offensive. The cumulative effects of the breakwater appear to have minor importance to the overall importance of the area.

Therefore, the District concludes that the general public's view is more or less neutral on the aesthetics of the breakwater, and a structure of this type is expected to be found in the harbor environment in which it is located. For these reasons, no further consideration of mitigation for aesthetic enhancement is required.

# SUMMARY AND CONCLUSIONS

## GENERAL

The latest Vermilion Harbor improvements were completed in July 1974, and consisted of channel widening and deepening and construction of a detached breakwater. These improvements were authorized to benefit the existing navigation project. The purpose of this study was to determine whether or not the detached breakwater is causing any adverse effects for which mitigation measures should be considered. The study evaluated the impact of the breakwater on: municipal water supply, pollution of recreational swimming areas, ice formation and jamming, free-flow flooding, sedimentation, navigation, and aesthetics.

Subsequent to the latest construction, there have been repeated complaints that the breakwater is causing serious, environmental, health, and recreational problems in the adjoining area. This study examined each impact identified and concludes that of these identified impacts, no mitigation of damages is warranted. A brief summary and conclusions regarding each of the identified impacts is presented in the following subsections.

## MUNICIPAL WATER SUPPLY

There is no evidence that the treated water supplied to the residents of Vermilion has ever been unsafe to drink. Construction of the breakwater has altered the pattern of dispersion of Vermilion River water into Lake Erie. Under certain wind, flow, and/or ice conditions, the concentration of river water reaching the intake is increased relative to before breakwater construction, while under other conditions the amount of river water reaching the intake is reduced.

The breakwater has altered the pattern of dispersion of river water into Lake Erie. This affects the timing but may or may not alter the frequency and concentration of river water reaching the municipal water intake. The Vermilion water treatment plant has the capability and history of producing safe water at all times. Therefore, remedial measures are not necessary and mitigation of the impact of the offshore breakwater on the municipal water supply is not warranted.

## SWIMMING AREAS AND BEACHES

Alteration of the river water dispersion pattern resulting from construction of the breakwater has a bearing on the quality of water in the recreational swimming areas adjacent to the river mouth. Quantitative water quality parameters for the beach areas in Vermilion are limited to fecal

coliform counts. These data indicate that Vermilion area beaches experienced poor water quality on occasion prior to and following construction of the offshore breakwater.

Data from City Beach (Main Street) suggests that this recreational area is not significantly affected by the breakwater. Water quality problems at this location are often experienced during prevailing southwesterly winds when the Vermilion River could not be the source of pollution.

Detailed analysis of water quality data and nearshore current patterns indicate that the Lagoons and Linwood Beaches to the east of the harbor are affected by the Vermilion River. Current patterns during westerly and southwesterly winds have been altered by the breakwater, resulting in transport of river water to the beach areas. Prior to breakwater construction, winds from these directions forced the area of river influence farther offshore.

The Buffalo District concludes that although the breakwater does deflect the river discharge to Lagoons and Linwood Beaches for west to south wind conditions, as well as increasing turbidity and debris, there does not appear to be a significant change in the water quality from a public health standpoint. No instances of "unsafe" postings for public health or turbidity and floating debris have been recorded since construction of the breakwater, so there has been no quantifiable recreational damages caused by the breakwater. Therefore, the District concluded that mitigation of the impact of the breakwater on beach pollution is not required, and should not be considered further.

ICE JAM FLOODING

The formation and behavior of ice is of great significance in small-boat harbors throughout the Great Lakes. In the Vermilion River, the severest problem associated with ice is the potential for ice jams and subsequent flooding.

Generally, the river channel area becomes solidly frozen sometime in early January. From this time on, the primary motion of ice is in the lake, where continuous breaking up and transporting of blocks with the winds and currents takes place. Since the breakwater has been constructed, during most winters the entire nearshore lake area becomes frozen, and windrows may form significant "walls" near the harbor mouth.

The process of ice breakup is initiated by high temperatures and/or rainfall melting and weakening the ice. Ice is broken by the hydraulic force of the river into blocks and sheets, which flow with the river currents until they reach the open lake or get stuck on some obstacle. Ice frequently jams at the many obstacles, channel constrictions, and bends present in the Vermilion River. It has been shown that the breakwater has not had a significant effect on transport in the river channel since the critical factors have not been affected.

Unlike the river channel, the area adjacent to the harbor jetties has undergone major change in regards to ice formation since the construction of

the offshore breakwater. While the strong, thick ice blockage was previously across the northern ends of the harbor piers, the addition of the breakwater has served to displace the windrow ice 200 to 500 feet to the east and west of the jetties.

When a major ice jam forms, the blockage must be freed to alleviate the potential flooding due to the water level rise upstream from the jam. The citizens of Vermilion have relied on ice breaking vessels in the past; these include a small city icebreaker, steel-hulled fishing boat, a 60-foot tug boat, and, on occasion, a 110-foot U. S. Coast Guard ice breaker.

The Coast Guard ice breaking fleet on Lake Erie is presently in a state of change. The Coast Guard reports that the 110-foot class vessels used in the past will be replaced with a larger, more efficient vessel class. The larger 140-foot class icebreaker has a 12.5-foot draft and requires a 15-foot water depth for safe ice breaking operation. This changed condition is not dependent on the detached breakwater and its impacts cannot be handled under this report. The appropriate legislative authority would be Section 216 of Public Law 91-611 (River and Harbor and Flood Control Act of 1970) which, when found advisable, authorizes a review of and report to Congress on the operation of completed projects with conditions that have significantly changed. This report to Congress should be in the form of a separate letter report on the modification of the existing navigation project due to changed ice breaking operations by the U. S. Coast Guard. Congressional Authorization is required to perform the additional deepening.

In summary, the location of potential ice jams in the harbor mouth region has been affected by the breakwater. Jams used to occur at the pier ends; they now occur anywhere from the pier ends to the east end of the breakwater. The primary problem is still to provide an outlet to the lake for the ice. Efforts to provide this path appear to have been hampered by the curved alignment of the new east lake approach channel. The probability of jams occurring is now less than in the prebreakwater period, due to elimination of windrow at the mouth. However, when serious jams occur, more difficulty is expected in breaking them up.

FREE-FLOW FLOODING

Based on the studies performed by Stanley Consultants, it is concluded that the detached breakwater has a negligible effect on free-flow flooding in the developed areas along the Vermilion River. Therefore, no further consideration of mitigation for free-flow flooding is warranted.

However, it must be recognized that flooding along the river will occur when the river channel capacity is exceeded such as happened in July 1969 and at other times before the breakwater was constructed.

SEDIMENTATION

The natural backwater effect of Lake Erie enhances sedimentation in both the river and lagoon area by reducing the hydraulic gradient and slowing the velocity of the river. In the period following construction of the

breakwater, scouring action during periods of high discharge has kept the main (center) channel close to project depths. Bends in the river, however, have shifted somewhat by eroding on one side of the river, with sediment buildup on the other. This is caused by natural processes and is not influenced by the breakwater.

Since the breakwater has no significant effect on the flow velocity in the Vermilion River, it has no effect on the rate of sediment accumulation in the lagoons or river channel. Therefore, mitigation of sediment accumulation in the lagoons and river channel is not required. However, it appears that the offshore breakwater does cause some sedimentation in the lake approach channels and may possibly increase the rate of sediment accumulation along the edge of the river entrance channel near the east pier. Since mitigation of this effect is already provided in the form of periodic maintenance dredging, it is concluded that no further action is necessary for mitigation of additional harbor sedimentation caused by the detached breakwater.

## NAVIGATION

The overall conclusion of the investigation is that the breakwater has accomplished its design purpose of providing an area sheltered from high waves and surge.

Several adverse effects on navigation have also been identified. A congested zone between the breakwater and the piers has been created, and zones of limited visibility now exist at the ends of the breakwater. The approach channel alignment now involves two turns, a factor which is particularly important when visibility is limited.

The majority of local boaters contacted felt that the beneficial aspects of wave and surge reduction outweigh the inconvenience associated with occasional congestion and the requirement for increased caution in the vicinity of the breakwater. It is concluded that no significant hazards to navigation have been created by the presence of the breakwater and consideration of specific hazard mitigation measures is not warranted.

## AESTHETICS

The question of whether the overall beauty of the area is enhanced or degraded by the breakwater is very subjective. The general feeling among boaters and residents is that the breakwater was designed as a functional structure and that it is typical of marine appurtenances, being neither beautiful nor offensive. The cumulative aesthetic effects of the breakwater appear to have minor importance to the overall appearance of the area, and no consideration of mitigation measures is warranted.

# RECOMMENDATIONS

Based on the studies performed and the conclusions reached as a result of these studies, recommendations regarding the seven breakwater impacts studied are as follows:

a. No further consideration be given or action taken on mitigation for:

(1) Contamination of the Vermilion Municipal Water Supply;

(2) Pollution of adjacent swimming areas and beaches;

(3) Ice-Jam flooding;

(4) Free-flow flooding;

(5) Hazards to navigation;

(6) Aesthetics.

b. For sedimentation, continue the authorized harbor maintenance dredging program.

c. If requested by the local sponsor, a separate letter report be prepared by the District specifically to obtain Congressional authorization under Section 216 of the River and Harbor Act of 1970 to deepen the East Lake Approach Channel and the Entrance Channel from -12 feet LWD to -15 feet to permit ice breaking operations by the new class of 140-foot Coast Guard vessel recently introduced on the Great Lakes. It is emphasized that no action would be required at Vermilion Harbor if the 110-foot cutter previously operating on Lake Erie had not been replaced by the Coast Guard. Thus, the proposed action is to maintain the status quo for ice breaking operations and not to provide a betterment.

Robert R. Hardiman
ROBERT R. HARDIMAN
Colonel, Corps of Engineers
District Engineer

Vermilion Harbor
Vermilion, Ohio

Impact Study of the
Detached Breakwater

# APPENDIX A

## General Correspondence

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

*Vermilion Port Authority*

CITY HALL
736 MAIN STREET
VERMILION, OHIO 44089
AREA CODE 216 / 967-5517

May 1, 1980

Donald M. Liddell
Chief, Engineering Division
Department of The Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York, 14207

Dear Mr. Liddell:

Thank you for providing copies of Tetra Tech's Draft Report of April 1980 to each member of the Vermilion Port Authority.

You requested our comments by 25 April 1980, however, some of us did not receive our copies until as late as 22 April 1980.. Even though we called a special executive work session on 24 April, two to three days did not allow enough time to properly review this report in a manner which it deserved.

It would appear to us that Alternative No. 3 would be our choice only because of the benefit/cost factor. This is not to say other alternatives might have been a better choice over the long term had we had more time for study.

One alternative the report did not cover that might be worth investigating is the beach nourishment method used at Cedar Point a few years ago. Specially shaped solid concrete units were laid end to end parallel to the beach which trapped sand within a short period of time resulting in a wide sandy beach. This could provide a buffer zone between the water line and the bluffs. These units were manufactured by Campbell Construction Company of North Ridgeville Ohio.

Thank you again for your consideration. We apologize for not meeting your deadline. If, in the future, it would be possible to allow us at lease two weeks lead time, perhaps our review and comments would be more meaningful.

If we can be of any assistance in any way, please contact us. The present mambers of the Vermilion Port Authority are interested and eager to do all we can to cooperate with the Corps of Engineers and see Vermilion's harbor and shore line improved.

Sincerely,

Warren Wood

Warren L. Wood, Chairman
Vermilion Port Authority

[illegible]
Checked By
Filed By

WLW:bz

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER(osr)
Ninth Coast Guard District
1240 East 9th St.
Cleveland, Ohio 44199
Phone: 216-522-3981

16150
1 April 1980

Colonel George P. Johnson
District Engineer, Buffalo District
Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

My staff has reviewed Tetra Tech's Draft Report of Special Impact Study on Ice Jam Flooding in Vermilion Harbor, Ohio (Feb 80). We offer the following comments with regard to the icebreaking proposals within the Study:

a. A 75-foot channel is extremely narrow for transit by an icebreaker with a 38-foot beam, especially when unmarked by buoys. At the least, provision for a range may be required as an aid to safe navigation of the channel.

b. The control in backing of a 140-foot class icebreaker is poor without a well-defined stationary track through which to back. Again, the 75-foot channel would present a problem under most ice conditions.

c. From an icebreaking standpoint, a breach detached breakwater (Alternative 2) would have advantages (e.g., a straight-in approach, and probably less need to maneuver shoreward of the breakwater). However, the effectiveness of that alternative in preventing flooding would not appear any better than that of 2B.

d. As has always been the case, wind, temperature, snow cover, river volume, and the level of Lake Erie will be factors in the success of each individual icebreaking attempt.

e. We concur with the Study's suggestion that the City of Vermilion upgrade its local flood relief capabilities to whatever degree possible.

Thank you for the opportunity to comment on the Study.

Sincerely,

R. A. Bauman

R. A. BAUMAN
Captain, U. S. Coast Guard
Chief, Operations Division
By direction of Commander,
Ninth Coast Guard District

March 27, 1980

Colonel George P. Johnson, District Engineer
Department of The Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York, 14207

Dear Colonel Johnson:

Thank you for furnishing a copy of Tetra Tech's draft report to each of the members of the Vermilion Port Authority.

It is our opinion, based on this report, that the advantages of the breakwater out-weigh the disadvantages.

It appears Alternative I would be the most desirable so long as dredging out the west channel would be included in the operation to provide for Route I. Deepening this channel would provide better ingress and egress for the ice breaker, provide an alternate route and improve flow of flood water and ice out of the river.

While we realize there would be considerable cost for rock removal, we question the $55.00 unit cost. A more reasonable estimate would be $14.00 to $16.00. Furthermore, there is a definite probability that relatively little or no rock would need to be removed.

As to any alterations to the wall, it is our collective opinion and the opinion of most boaters in this area that the lighting is totally inadequate, even though it meets regulation. The wall is a safety hazard at night, as is the unlighted can bouy in the west channel. This bouy has been hit many times and nearly caused collisions with other boats on several occasions.

Again, we appreciate the opportunity to work with the Corps in resolving our difficulties. If there is anything we can co, please don't hesitate to contact me.

Sincerely,

Warren Wood

Warren L. Wood, Chairman
Vermilion Port Authority

WLW:bz

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Area Code 412

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334 BOULEVARD OF THE ALLIES
PITTSBURGH, PA. 15222

February 12, 1980

Senator Richard S. Schweiker
Senate Office Building
Washington, D. C. 20510

Subject: Vermilion Monstrosity
(Vermilion, Ohio Harbor)
Reference: Breakwall

Dear Senator Heinz,

Enclosed please find copy of a commentary by Mr. George Grossman of Cleveland, Ohio relative to the above subject. In this commentary, he makes several accusations against the Corp of Engineers, relative to covering up the change in channel. He also points out that, with the new ice-breakers, it will be impossible to get them behind the breakwall. This is true.

With the information, and it had to be realized from the beginning, available, the installation of this breakwall had to be ridiculous.

How long do we, as private citizens, have to fight a government agency, to get one of their "goofs" corrected?

We thank you for reading the attached, and for any help that you can provide to get this thing corrected, or eliminated.

I thank you.

Yours very truly,

J. W. Rutledge

JWR/lkr

1712 Amber Drive
Cleveland, Ohio 44111

January 21, 1980

# WHY THE "IMPROVED" VERMILION HARBOR IS INHERENTLY HAZARDOUS FOR COAST GUARD ICE-BREAKING OPERATIONS

by George W. Grossman

1. At the request of local interests, Vermilion Harbor was "improved" in 1973 with a breakwater and associated changes in the navigation channels. The plans for these changes are shown in Exhibit A. During the final design stage, a turning basin for Coast Guard ice-breakers was considered which would require additional funds. The Coast Guard also stated on 27 October, 1970 that "operations in Vermilion Harbor are inherently hazardous and not necessarily within the capability of our vessels." (Exhibit D)

Despite this warning, plans for "improvements" went forward and the final design, Exhibit A, was approved April 6, 1971. The Vermilion Port Authority stated that the plans "present accurately and precisely all details of the Vermilion Harbor project as agreed upon ..." (Exhibit E)

2. The final design plan shows a primary lake approach channel 12' deep below low water datum with an approach to the harbor on a SW course. This plan thus required the Coast Guard to make a 45° right turn to enter the harbor, followed by a 90° left turn to enter the river channel.

3. The Jan. 30, 1979 public notice on dredging and the Dec. 3, 1979 sounding chart (Exhibits B & C) show that the lake approach channel has been moved to provide an approach on a due south course. A Coast Guard vessel must now execute a 90° right turn and then a 90° left turn to enter the river channel. The centerlines of these turns are displaced by a distance of only 525 ft. No Coast Guard vessel 110' long can execute two such 90° turns in confined water except at a very low speed.

4. The reason for changing the position of the lake approach channel is apparent. A SW approach as shown in Exhibit A requires passage over a rock outcropping (Exhibit C) only 10' below LWD. The 110' Coast Guard vessels draw 12' of water and would risk running aground in the designed channel. Removal of this rock shoal would necessitate expensive drilling or blasting. To avoid such expenditures, the Corps simply changed the location of the lake approach channel.

5. On Dec. 18, 1974, the Corps filed initial plans with the Chart Branch of the Dept. of Commerce, showing the approved channel. On March 20, 1975, the branch received a revised Corps Drawing 64-VER-2/1 showing the change in the approach channel. Vermilion is in the legal jurisdiction of the Vermilion Port Authority. Ohio law requires that any changes in a harbor be given public notice and public hearing. There was no public notice or hearing and, to my knowledge, the Port Authority was not informed of the change.

6. The change in channel location had an obvious adverse environmental impact. The change increased the flood hazard to Vermilion by making it more difficult for ice-breakers to enter the harbor. Under federal law, an environmental impact statement should have been made prior to the change. The Corps did not do this.

7. The change in channel was made prior to the Sept. 1975 draft EIS on operation and maintenance of Vermilion Harbor. This important EIS was apparently falsified to show the harbor as in Exhibit A.

8. Subsequent harbor studies by Stanley Consultants submitted in May, 1978 and April, 1978 purported to show the entire history of the harbor to 1976 but they failed to mention this important change officially filed on March 20, 1975. Fig. 1 in each study was very carefully drawn to show a portion of the approved channel by cross-hatching and dotted lines and the revised channel with dotted lines only. The existence of the change was shown but was completely concealed except to very close examination by someone with engineering knowledge.

9. Chapter 5 of the April, 1978 "impact" study is titled "Impact of the Offshore Breakwater on Ice Formation and Jamming" constitutes 32 pages of very excellent technical analysis. Much of this chapter is concerned with ice-breaking. (Exhibits F & H) There is no mention of the change in channels in this chapter, although the change increased the difficulty of ice-breaking operations. It would seem that the Corps instructed Stanley Consultants to conceal knowledge of the change from the public.

10. At the low speeds now required to make the turns into Vermilion Harbor, winds and currents become very critical factors in navigation. With a crosswind or crosscurrent, a ship's heading must be corrected to obtain a given course. The lower the forward speed of the vessel, the greater the change in heading needed to achieve the desired resultant course.

Such course corrections are easy to obtain in a straight-in, power-on approach, particularly with range lights as guides. In the limited area and gusty winds of Vermilion Harbor, any Coast Guard skipper entering the harbor with a 110' tug has to be counted as a gambler. The Coast Guard has entered the harbor with ice-breakers and might enter again but there is no time or space to correct a course for winds or current. Navigating a 110' tug in Vermilion Harbor is a risky business not consistent with the Coast Guard's strict "safety of the vessel" attitude. (Refer to Exhibit D)

11. An existing ice jam behind the breakwater also presents a hazard for the Coast Guard. A jam could let go and force a boat into the breakwater. Exhibit F shows how the breakwater has increased the number of potential locations for ice jams.

12. Adequate channel depth for ice-breakers is an obvious need which has received much local attention. The Dec. 3, 1979 soundings (Exhibit C) were taken immediately after $300,000 of dredging. These soundings thus represent the best available conditions. However, the harbor is known to fill in with sand very quickly. The October, 1978 dredging filled back in by Dec. 22, 1978 (Refer to Corps soundings). A Coast Guard cutter 110' long will not enter in 1980-81 without another dredging job next fall.

Furthermore, the east channel, even when dredged to 12' below LWD, will not be deep enough for ice-breakers when Lake Erie is at its long-term average mid-winter level of 1' above LWD. (Exhibit G) Thirteen feet of water simply isn't enough for a boat with a 12' draft. The lake is now extremely high at 3' above LWD but this will not always be the case. The new 140' ice-breakers now coming into service will not be able to enter Vermilion Harbor at any time.

13. The ice formation and ice-breaking problems created by the breakwater have been graphically summarized by Stanley Consultants in the "impact" study on Vermilion Harbor. (Exhibit H) It is a simple matter for engineers hired by the Corps to draw a picture of an ice-breaker zig-zagging into Vermilion Harbor. Unfortunately, it is not that simple in practice. Entering between the piers to break a jam is impossible most of the time.

## Conclusion

Under existing conditions, the most that the City of Vermilion can expect from the Coast Guard is that the Coast Guard break ice only to the east end of the breakwater. Anything more involves unacceptable hazards to Coast Guard vessels at nearly all times.

1. In the planning stage, the Coast Guard described ice-breaking conditions as "inherently hazardous".

2. When plans for "improvements" were submitted, the Coast Guard recognized the increased hazard and recommended a turning basin for ice-breaker operation.

3. Faced with additional costs in removing rock from the approved channel, the Corps revised the lake approach channel to make ice-breaking even more difficult. This change violated federal environmental law. The change was not made with approval of the Vermilion Port Authority and the public and thus violates Ohio law.

4. The subsequent environmental impact statement for operation and maintenance of Vermilion Harbor was falsified by a showing of the wrong approach channel. This statement stands in violation of federal law.

5. The Corps subsequently prepared studies on Vermilion Harbor which deliberately concealed notice of the channel changes from the public. This constitutes abuse of discretion and possibly a criminal offense of conspiracy.

6. The conduct of the Corps has endangered the public health and safety in Vermilion by increasing the flood hazard to Vermilion. The Mayor, City Council, the Port Authority, and interested citizens must act immediately to have some or all of the breakwater removed to minimize the flood hazard.

ADEQUATE GROUNDS EXIST FOR SUCH ACTION BY THE CITY.

# Preparing for Ice

THE RARITAN on Lake Erie near Vermilion's Harbor. (Journal Photo by Daniel Ho)

## *Coast Guard Cutter Tours the Vermilion Harbor*

By PATRICIA TRAINA
Journal Staff Writer

VERMILION — With the wind crashing and the spray washing over its decks, the 110-foot Coast Guard cutter, The *Raritan*, *cruised* into Vermilion yesterday.

The ship's crew was touring the Vermilion harbor to familiarize themselves with the area in case they are called back in the future to help with possible emergency flood situations.

The trip from The Raritan's home base in Cleveland to Vermilion was arranged by Mayor Hobart Johnson, George Phillips, service director and head of the city's own ice-breaking operation, and Dick Bulan, of the Port Authority, as part of a comprehensive flood control program.

The ship could *not* enter the harbor yesterday, due to *strong southerly* winds which might have *blown* The Raritan into the piers or the breakwater if she tried to enter the narrow channel. However, Captain James Sebastian did *say he* would do whatever he could for the city if ice begins to jam the Vermilion River and *cause flooding*.

"I am confident we'll be able to stick our nose in behind the breakwater (to break up ice and create a path for more ice flowing from the river to the lake) but just how far in we can go, I can't say."

He indicated the ship might be able to come in about 100 feet, the length of the ship. "~~But weather conditions would have to be ideal.~~ The way I see it now, ~~you'll never see~~. The Raritan in the ~~mouth of the river~~."

He said the ship would not be able to get into the river itself — not because the *channel* is too shallow — but because there isn't enough room for the big ship to maneuver in.

The channel between the eastern pier and the breakwater is only about 300 feet wide *which* doesn't leave much margin for error. If The Raritan were to enter the river, it would have to back out because there isn't room enough to turn around.

"If we were to go in there and an ice jam let loose," Sebastian said, "there would be no way we could get out. We'd become a monument there."

Although Phillips and Johnson said they were very satisfied with their morning's work — they, along with Bulan, accompanied the crew from Cleveland — ~~they~~ they were disappointed that the ship couldn't *enter* the harbor.

Phillips said he had been encouraged by previous conversations with Sebastian. The captain was in Vermilion Tuesday, sans ship, to take some depth soundings and determined the river channel was deep enough for The Raritan, which draws about 12 feet of water.

"I thought we'd get more assistance," he said, "but you never know. It all depends on the weather."

He said he was very pleased with the Coast Guard's cooperation, however.

Because of the mild weather, Phillips doesn't expect any flooding problems in the immediate future, but said ice could still form on the river until about the second week of February.

# *The City of Vermilion*

CLERK'S OFFICE
P.O. BOX 317
VERMILION, OHIO 44089

JUNE C. RINI
Clerk of Council

September 19, 1979

Lt. General John W. Morris
Chief of Engineers
Army Corps of Engineers
1000 Independence Avenue, S.W.
Washington, D.C. 20314

Dear Sir:

Enclosed please find a certified copy of Resolution #79R-13 requesting the Corps to prepare a comprehensive and updated environmental impact study, which was passed by Vermilion City Council at their meeting of September 17, 1979.

Your immediate attention will be appreciated.

Sincerely,

June C. Rini

June C. Rini
Clerk of Council

jcr
enclosure
cc: Col. George P. Johnson, District Engineer
Senator John Glenn
Congressman Donald Pease
Mr. George Grossman

# RECORD OF RESOLUTIONS

National Graphics Corp., Cols., O. national graphics Form No. 1133-A

*Resolution No.* 79R-13 *Passed* September 17 19 79

A RESOLUTION REQUESTING THE UNITED STATES ARMY CORPS OF ENGINEERS TO PREPARE A COMPREHENSIVE AND UPDATED ENVIRONMENTAL IMPACT STUDY AS RELATES TO THE BREAKWATER CONSTRUCTED IN THE MOUTH OF THE VERMILION RIVER FOR THE REASON THAT THE SAME HAS PRECIPITATED CERTAIN ADVERSE ENVIRONMENTAL EFFECTS WHICH WERE UNANTICIPATED; REQUESTING THE CORPS TO ADDRESS BOTH FLOODING AND POLLUTION AND BEACH EROSION AS A TOTAL AND OVERALL ENVIRONMENTAL PROBLEM AND DECLARING AN EMERGENCY.

WHEREAS, it has become evident to responsible citizens and officials of the City of Vermilion, Ohio, that certain adverse environmental impacts have occurred as the result of the construction of a breakwater at the mouth of the Vermilion River.

WHEREAS, certain beach erosion has taken place in proximity thereto and severe, far-reaching, and calamitous flood hazard have nearly been avoided.

WHEREAS, the silting of the Vermilion River in the area of the breakwater precludes efficient and effective ice breaking operations by the United States Coast Guard.

WHEREAS, if the United States Coast Guard is unable to break ice in the Vermilion River in the vicinity of the said breakwater, the potential for calamitous flooding conditions resulting in the far-reaching loss of property and threat to human safety is inevitable.

WHEREAS, this City Council believes that a comprehensive re-evaluation of said breakwater is imperative in order to protect persons and property located within the corporate limits of the City of Vermilion and to assure access to the mouth of said River to the United States Coast Curad.

NOW, THEREFORE, BE IT RESOLVED by the Council of the City of Vermilion, Counties of Erie and Lorain, State of Ohio:

SECTION 1: That acting on behalf of itself, the City Administration, and all concerned citizens of the City of Vermilion, Ohio, this Council hereby requests and implores the United States Army Crops of Engineers to undertake, prepare, and furnish to this City a current, updated, and meaningful environmental impact statement under 40 CFR 1500.13 as relates to a breakwater constructed at the mouth of the Vermilion River wherein this Council hereby declares that unanticipated adverse environmental effects have occurred. It is requested that the Corps of Engineers undertake a comprehensive evaluation at the benefits from said breakwater as opposed to adversed environmental effects from the perspective of the costs to modify or amend such structure. It is further requested that said study address itself to the breakwater's impact and potential affect upon flooding, ice breaking, pollution, and erosion assessments and that the same be done as a single overall evaluation. It is hereby requested that such study be undertaken as expediently as possible and that the Corps solicit imput from concerned and adversely affected local citizenry as well as from the United States Coast Guard, whose ice breaking operations have become definitely impaired due to silting at the mouth of the Vermilion River in the vicinity of said breakwater.

SECTION 2: That this Resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety and welfare of the City of Vermilion and the inhabitants thereof for the reason that it is immediately necessary to fully evaluate any adverse environmental impacts of said breakwater which were unanticipated in order protect persons and property within the corporate limits; and provided it receives the affirmed majority vote of two-thirds or more of those members elected or appointed to City Council, it shall take effect and go into full

National Graphics Corp., Cols., O. national graphics Form No. 6233-A

*Resolution No.* 79R-13 *Passed* September 17 19 79

Page 2.

force immediately after its passage and its approval by the Mayor; otherwise it shall take effect at the earliest period allowed by law.

PASSED: 9-17-79 Margaret P. Shafts
President of Council

ATTEST: September 17, 1979 June C. Bene
Clerk of Council

APPROVED: 9-17-79. Jim Odum,
Mayor

I hereby certify this to be a true and exact copy.

June C. Bene
Clerk of Council
City of Vermilion, Ohio

George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111

September 7, 1979

Mr. George Watts
Tetra Tech, Inc
1911 N. Fort Myer Dr.
Arlington, VA 22909

Dear Mr. Watts:

I enjoyed our phone conversation and was pleased to learn that Tetra Tech is getting the Vermilion studies underway. I understand that you will not be collecting much additonal field data. The most important elements that Tetra Tech can add to the existing data are a presentation of the historical shoreline contours and the before and after soundings from the fall dredging. We need to know how quickly the east channel fills in after dredging as this has bearing on the urgency of mitigation of beach erosion.

I would like to convey my opinion of the accuracy and usefulness of various parts of Stanley Consultants' work in the Stage 2 Impact and Section 111 studies. My observations cannot be considered unbiased but they have a certain validity. I have read and reread these reports and compared them with what I see.

*Observations on the Stage 2 Impact Study*

Chapter 2 - Impact on Water Supply - The data is good. Conclusion ignores point that warmer river water travels on bottom during ice cover period. The breakwater has affected water quality. However, conditions are within control of water plant operator except for about one week after ice breakup.

Chapter 4 - Impact on Swimming Area - Reasonably accurate data. Conclusion ignores point that river flow is almost always diverted eastward. Light NW to NE winds cause the most objectionable conditions. Swimmers simply do not go in the water. In the absence of pre-breakwater data, the increase in pollution from the breakwater cannot be measured. A court has held that the breakwater has increased beach pollution but no one can say how much.

Chapter 5 - Ice-Jamming - Excellent work. Figures 5-8 and 5-9 tell it all. When ice travels laterally along the shore as in Photo 5-1, it will be trapped behind the breakwater. The breakwater did not eliminate windrows, it simply changed their location. We have not had severe windrow conditions in the last six years due to warm weather or complete ice cover. I've seen 15' high windrows on the Lagoons beach in pre-breakwater days. Similar conditions will fill the east channel with ice as in Figure 5-9. This chapter should be updated with the 12' draft and 140' length of the new Katmai Bay class ice breakers. This could be the only ice breaker available by the winter of 1980-81 according to the Ninth District Coast Guard. The new boats will have trouble entering Vermilion Harbor in ice even with the channels at design depth.

Chapter 6 - Flood Potential - I do not have the hydraulics knowledge to evaluate this. From first hand observation of the 1969 flood, I believe the problem is understated. I think a summer flood will pile up boats and trailers behind the breakwater. These traveled 1/2 mile out into the lake in 1969.

Chapter 7 - Sediment Deposition - Good data but I question whether wave agitation did not aid in cleaning out private channels in pre-breakwater era. This section should be updated with 1978 and 1979 dredging data.

Chapter 8 - Navigation Hazards - Correct in concluding that breakwater does not constitute a navigation hazard to "the knowledgeable, well-prepared, cautious boater." However, many incautious boaters found the breakwater to be of no assistance on August 5, 1979.

Chapter 9 - Aesthetics - Inconsequential.

Observations on the Stage 2 Section 111 Report

This report is characterized by Stanley Consultants' recommendation, P. S-4, that "assuming the beach is acceptable in its present state of equilibrium no further consideration of mitigation for beach erosion is required." Even the Corps couldn't buy that and subsequently agreed that mitigation was warranted. The most outrageous errors are contained in Table 3 and Figure 14 wherein good horizontal plane historical shoreline data is "converted" to a vertical reference elevation, low water datum. The October 1937 and April 1968 aerial photos are almost identical and Figure 14 shows how much error is introduced by this conversion. Since Tetra Tech will be required to consider mitigation west of the piers, you should be aware that the Figure 14, historical position of low water datum contour, has no relation to reality west of the piers.

The Stanley study carefully excludes all consideration of the beach that extended from 30+00E to 38+00E in pre-breakwater days. Even the aerial photos showing this beach are omitted. The available aerial photos refute essentially all of Stanley's theoretical work and therefore they were all omitted. To explain away the accretion that apparently occurred west of the piers from 1837 to 1854, (Figure 14), Stanley calls the 1835 shoreline an estimate from "a poorly referenced historical chart." Actually, the 1835 drawing is copied from an 1833 Corps survey that has numerous reference points.

To use the Stanley Stage 2 report, Tetra Tech should simply discard all of the theoretical data and derived data such as the "historical LWD contour". Table 6, for example, shows that the net littoral drift is east, leading to a presumption that the westward shift is just a temporary aberation. On the other hand, Figure 16 shows a net flow westward around the pier from 1937 to 1968 while Figure 11, Sta. 0+00 shows that sand did not extend any closer than 270' to the end of the east pier in 1967.

I would hope that Tetra Tech's Stage 3 report contains the historical aerial photos and an accurate plot of the historical shoreline contours. This is what you have delivered to the Detroit District. With this information, anyone can understand what is happening. A post-dredging contour will be of further help.

The following figures and tables in the Stage 2 report have value:

Fig. 3 - Shows how refraction around the dips in the 4 and 6 contours has kept the beach from forming a large fillet at the east pier in pre-breakwater era. Also shows 200:1 and 100:1 offshore slopes that keep the sand on the shore.

Fig. 11 - Shows pile-up of sand at east pier and extension of sand into navigation channels.

Table 9 - Observed data only. Shows that beach angle hasn't changed due to breakwater at Sta. 7, 18+00E. Indicates that groins will work and that design shoreline azimuths should be 88° and 85°.

I hope these observations are useful to you. I'll admit to a prejudice about engineering practice that contrives theoretical data to support a predetermined conclusion when the observed data doesn't fit. Reviewing the Vermilion Stage 2 Section 111 report invariably increases my blood pressure. However, reviewing the work you've done for the Detroit District and the Michigan shoreline is encouraging.

I hope that your two Stage 3 reports arrive at a joint conclusion that removal of the breakwater is warranted. However, the enclosed letter to Colonel Johnson indicates that groins with artificial fill would permit us to survive in coexistence with the breakwater. Tetra Tech has done an admirable job for the Michigan shore of Lake Michigan with sand transport. On Lake Erie, we lack the sand supply that exists on Lake Michigan. Much of the shoreline is armored and dredging removes more sand than is supplied by erosion of bluffs with 5% or 10% sand content.

Groins and sand fill are the only hope for the Ohio shore of Lake Erie. However, no one has evolved a groin design suitable for shale bottoms other than rubble-mound. We need some imaginative, low cost groin designs that can be used by public agencies and private individuals. I hope your studies will develop something of this nature for the Lake Erie shore.

Sincerely yours,

George Grossman

George W. Grossman

Enc.

cc: Colonel George Johnson

# Linwood Park Cottage Owners Association, Inc.



August 22, 1979

STATEMENT FOR HEARING FILE
AUGUST 14, 1979 PUBLIC HEARING
DREDGING OF VERMILION HARBOR

Colonel George P. Johnson
U. S. Army Corps of Engineers
Buffalo District
1776 Niagara St.
Buffalo, New York 14207

Dear Colonel Johnson:

We would like to review the issues brought up at the August 14, 1979 public hearing on Vermilion Harbor, summarize the comments, and then make recommendations as to how we feel that the issues can be met by the Corps.

Issue #1 - Will dredging be effective?

The purpose of dredging was said by some to be for entry of ice breakers. The Corps commented that dredging was required to maintain the design configuration. It was contended that dredging would not maintain design depths for any reasonable length of time.

Recommendation - Several soundings should be taken after dredging to determine how long the design depths remain. These sounding charts should be made available to the Vermilion Port Authority, and to the public as part of the Vermilion Public Library hearing file.

Issue #2 - Will dredging cause beach damage?

The Corps stated that of the 50,000 c.y. to be dredged, 15,000 c.y. is sandy mixture suitable for open-lake disposal. This contains beach sand and it is reasonable to estimate that perhaps 5,000 c.y. to 10,000 c.y. of beach sand will be removed by dredging.

Recommendation - The dredgings suitable for open-lake disposal should be sampled regularly and their sand content determined. Beach profiles before and after dredging should be taken. This information should be made available to local officials and the public as in #1.

Issue #3 - Can the sand be restored to the beaches?

Numerous comments asked for sandy sediments to be placed in updrift nearshore waters. The current open-lake disposal site was simply carried over from pre-NEPA days. This existing site is near a prime perch fishing area.

Recommendation - The Corps could consult with Mr. Ray Full, Kishman Fish Co. to determine if a site change would affect fishing. Mr. Full is the most knowledgeable expert available. If he felt that an alternate nearshore site was available, the District could prepare an environmental assessment and change the site.

Issue #4 - Should a new EIS be prepared on the breakwater?

The cost of the proposed dredging operation, and the costs of any damages resulting from dredging, are unanticipated costs resulting from the breakwater. A new EIS has been requested under 40 CFR 1500.13.

Recommendation - The Corps should prepare an EIS showing total present costs of the breakwater, and an accurate statement of total benefits.

Please place this statement in the hearing file.

Sincerely yours,

LINWOOD PARK COTTAGE OWNERS ASSN.

George W. Grossman

George W. Grossman, President

DON J. PEASE
13TH DISTRICT, OHIO

1641 LONGWORTH BUILDING
WASHINGTON, D.C. 20515
(202) 225-3401

COMMITTEE ON
INTERNATIONAL RELATIONS

SUBCOMMITTEE ON
INTERNATIONAL DEVELOPMENT
SUBCOMMITTEE ON
EUROPE AND THE MIDDLE EAST

ADMINISTRATIVE ASSISTANT
MRS. BETTE WELCH

# Congress of the United States
## House of Representatives
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July 18, 1979

Honorable Jim Odom
Mayor, City of Vermilion
Box 317
Vermilion, Ohio 44089

Dear Jim:

You will recall that on June 12th I sought advice from the Chief of Engineers, General Morris, concerning the proposed removal of the breakwall in Vermilion Harbor. Enclosed is the reply I received on July 5th from the Office of the Chief of Engineers.

Frankly, I'm disappointed in this response. As I read the letter from General Robinson, it essentially says that you have to ask the Buffalo district office of the Corps to remove the breakwall if that is your wish. And, upon receipt of that request the Buffalo office investigates the matter and makes recommendations. If the District agrees with your position and recommends a change, then the request has to go through the normal channels of the Corps of Engineers and the Administration (OMB), and then to Congress as part of the President's budget message.

In his final paragraph Robinson seems to say that the City's only alternative if it "disagrees with the Corps findings and conclusions" is to seek congressional relief---which really means an Act of Congress directing the Corps to do something different from what it feels needs to be done.

My first reason for unhappiness is the evident delay of the procedure they outline. That procedure has the sound of a protracted one to me. But, I don't see much hope for success of any procedure which would seek to shortcut that course of action. Theoretically, Congress can pass a law at any time with or without a report from the Corps of Engineers. However, in reality the House Public Works Committee and the Water and Energy Resource Subcommittee of the House Appropriations Committee are extremely unlikely to act---to either authorize or appropriate---without having a recommendation from the Corps of Engineers The second reason for my unhappiness is that the General seems to indicate that the only appeal process is to go directly to the Congress, which again means a battle, initially with the House Public Works Committee, which has traditionally had very close ties with the Corps of Engineers.



G1
DJL

Jim Odom
July 18, 1979

Page Two

It seems to me that the City has only two courses of action open to it; one, is to make a formal request to the Buffalo district office of the Corps asking for removal of the breakwall in order to se* in motion their review and investigative machinery. If you decide to follow that course of action I naturally will be more than happy to expedite the proceedings in every way possible.

Secondly, of course, the City has the right to file suit against the Corps of Engineers in a federal district court. Not being a lawyer I have no idea what the prospects for success may be but you might want to explore that with the City's legal counsel.

In conclusion, Jim, it occurs to me that the resolution passed by your City Council, on May 21, copy of which was to be "served upon" the Chief of the District's Corps of Engineers office, may in your judgement serve as your request to the Corps for removal of the breakwall. However, I would presume that a follow up letter to that action would be advisable.

Again, I repeat that this office stands ready to be helpful in any proper and possible way. I express the hope that you will continue to keep me informed.

Best personal regards.

Sincerely yours,

DON J. PEASE
Member of Congress

DJP:wsm
cc: June C. Rini

P.S. We just recently received the normal "Announcement of Public Hearing" from Buffalo advising of the August 14th hearing at the Vermilion City Hall, dealing with the "disposal of 50,000 cubic yards of dredged material from the Federal Navigation Channel at Vermilion". We will of course attempt to follow the outcome of that hearing with interest and concern.

13TH DISTRICT, OHIO

COMMITTEE ON
INTERNATIONAL RELATIONS

SUBCOMMITTEE ON
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SUBCOMMITTEE ON
EUROPE AND THE MIDDLE EAST

ADMINISTRATIVE ASSISTANT
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June 12, 1979

LTG. John W. Morris, Chief of Engineers
Army Corps of Engineers
1000 Independence Avenue SW
Washington, D.C. 20314

Dear General Morris:

I seek advice and guidance from your Office as to the policy of the Corps concerning a request new to us and briefly outlined below.

We are presented with a situation where the Corps of Engineers put in a harbor breakwall a number of years ago, and now the mayor and city council of the city have approved a resolution calling for removal of the breakwall.

Please advise me, at your earliest convenience, as to the Corps' general policy in situations of this sort. For example, what obligation does the Corps have to be responsive to city officials in such a request.

(1) If the Corps were to agree with their findings that the breakwall must be removed, would an additional appropriation be necessary to cover the cost, or could the Corps assume that responsibility within its already appropriated funds? (2) Would any additional authorizing legislation be necessary? (3) If the Corps disagrees with the City in question as to the desirability of retaining the breakwall, what recourse does the city have? And, (4) Is there a precedent for legal action by the city in a situation of this sort?

It is my understanding that years ago when the breakwall project was under study, the project was supported by the City. The strongly differing opinion now held by present city officials requires me to seek an answer to the questions outlined above.

I am aware that in August of 1978 the Corps completed a Study of the Impact of the Offshore Breakwater, addressing the problem under discussion here. It was determined in that Study that "the breakwater is adversely affecting two of the problem areas, ice-jam flooding and poor water quality in swimming areas east of the harbor," and "a study of possible mitigative measures for these problems will begin this fall". And, I am further aware that one or possibly more public hearings have been held on the matter.

6
DAK

You will note that I am not looking for a specific response from you concerning a particular project, but rather - and very importantly - I will appreciate having your reply as to the general policy of the Corps in such matters.

Thank you for your prompt reply, to assist me in an accurate and informative answer to my constituents.

Sincerely yours,

Don J. Pease
Member of Congress

DJP:bwm

# Vermilion mayor calls for end to breakwall 'monster'

By KATHY BYLAND
C-T Staff Writer

RMILION – In the wake of Sunday's Mayor Jim Odom Monday angrily called immediate removal of the Army Corps neers breakwall

ood out on the pier Sunday and (realwas standing on the monster that will drown this city," Odom told council.

Vermilion) is a test tube for the whole rie community. The breakwall was and constructed here by the political ion of certain people," Odom charged.

ASKING FOR the full support of in sending a letter to the Congress, and Corps asking for the removal of ll before...we go through a three to flood that we can't prevent," Odom

will submit to council a draft of the hich council president Alex Angney ill support.

g the height of the flood Sunday , homes in the Riverside Drive and Club area were flooded as well as most river-front marinas. Water rushed across Lake Road for about three hours. The lower dining room at McGarvey's Restaurant was also flooded when a huge ice jam broke loose at Mill Hollow and lodged at the bridge near the restaurant.

RIVERSIDE DRIVE and Olympic Club residents evacuated their homes about 1:30 a.m. Sunday, but many Lagoons residents, who were also warned to leave, stayed in their homes, Odom said.

Disaster was averted when the wall of ice hit the breakwall, made a right turn, jammed, then headed left of the breakwall and out into the lake.

"If it had stopped, the Lagoons and business district within seven to 10 minutes would have been under water," Odom predicted.

The mayor said he doubts a damage estimate will be set for the flood.

IN HIS REGULAR report to city council Monday, he vehemently denied accusations that city officials acted too slowly in handling the flood.

Odom said he and service director George Phillips first asked for a Coast Guard ice cutter Feb 23. Waving a five-page list of phone calls his office received since then, Odom told of calling the Corps, Coast Guard and even U.S. Rep. Donald J. Pease's Washington office for help.

Under the orders of the Corps, the Coast Guard cutter Kaw went first to Rocky River, then arrived in Vermilion Saturday to help break up ice.

"(The Kaw) left Saturday night. We didn't know where Mill Hollow was going at that point...I begged the Corps to bring the boat back, and they waited until 12 o'clock (Sunday)," he said.

ODOM ALSO POINTED out the personal risks the city crew took in attempting to break up the ice.

Workers were asked to sign a waiver that they would have no insurance protection if they drowned, Odom said.

Reading from a C-T article which appeared Friday, the mayor attacked the opinion of Theodore Wakefield that the breakwall does not cause flooding.

Odom charged that financial contributions over a period of many years influenced local politicians to build the west pier. The pier was built from federal funds and protects the area around Wakefield's property, yet residents are denied access because to reach the pier they must cross private property, he said.

"ALL GOOD CITIZENS contribute to the political parties and candidates they respect. I hope he (the mayor) does the same," Wakefield replied this morning.

While it is true that the public no longer has access to the west pier, Wakefield said none of the homeowners there had ever been seriously approached by the city to buy the property.

Wakefield also pointed out that the city had the chance to gain access to 220 feet of beach east of the pier through the Great Lakes Historical Society Museum. Odom vetoed the lease, saying there was no proof the city would have the money to maintain it.

The mayor also produced a Vermilion Port Authority study showing that the river dramatically decreased in depth between August and December of last year. The Coast Guard cutter needs a 12-foot depth to operate, but the river behind the break wall was much shallower, he said.

ODOM, WHO WAS applauded by many of the about 20 citizens who attended the meeting, was backed up by port authority member Dave Patterson.

"Let there be no doubt that the (cutter) Kaw was called away by the Corps of Engineers...I'm not too sure if the Corps really likes Vermilion," he said.

Also supporting the mayor was George Grossman, a long-time foe of the breakwall since it was built in 1973.

In a letter to the Corps dated Monday, Grossman charged that some residents have taken a "devil-may-care" attitude toward flood control.

"It is very unfashionable, and a show of weakness to tie up boats or make any preparation for a flood," he said.

# Valley Residents Begin Clean-Up

By BILL LAMMERS
*Staff Writer*

VERMILION — Vermilion River Valley residents were spending their time Monday cleaning up residue of the swelled river, which crested at 5 or 6 feet above normal Sunday before an ice jam became dislodged near the mouth of the river.

Although relieved the water has receded, many residents were searching for a person, agency or thing on which to place the blame for the flooding.

Betty Uebbing, 826 Riverside Drive, said the only possible action to take is "just a matter of cleaning up, I guess."

A huge block of ice had shoved the pillar under Mrs. Uebbing's porch about three feet back, forcing the family to prop up the home with blocks and a metal pole. Water also ruined a freezer in a building outside the Uebbings' home.

"It took all our grass and I had the walk (sidewalk) out to the river and it's gone now, too," Mrs. Uebbing, broom in hand, said as she surveyed the damage surrounding her and her neighbors' homes.

James Major, 1043 Riverside Drive, said he was lucky — his house, built on eight-foot, concrete block stilts, was pretty well protected from the water, although his property sustained some damage, probably in the hundreds of dollars.

Major's basement had 32 inches of water in it, which touched but did not significantly damage such items as a washer, dryer and a lawnmower stored there.

"When I get ready in the fall, I get everything up in the air," Major said.

Although admitting his losses mainly were the small things — a tree skinned up which may later die and a lawn lamp which now protrudes at a 45 degree angle — such losses as his tree become "quite a loss because it takes a long time to grow."

One family and its friends was making the best of a miserable situation Monday.

The sons and daughters of Mario and June Rini, Olympic Outing Club, on the west side of the Vermilion River, were cleaning Monday a basement which had more than 3 feet of water in it Sunday.

The family of 10 children were acting on their own because the parents, just finishing a two-week vacation in Florida, had not returned yet.

The freezer, washer and dryer were all damaged in the high water. The Rini family members were unable to place a dollar figure on the damage, but guessed damage, which included a room full of furniture, would be high.

"A lot of kids took off school to help clean up," one young Rini said. "It's fun cleaning up when you have friends."

One seemingly ignored victim of the flooding was a hapless trout, which was found by the Rini family as it searched for a place to lay its eggs. The Rinis returned it to the river, where it reportedly swam upstream to spawn.

**'We have a mayor who thinks the good Lord will take care of it.'**

*—one Vermilion resident*

Although the residents were trying to clean up as best as possible, they found many persons to blame for the flooding, ranging from the U.S. government to Mayor [illegible] Odom.

"If the damn Coast Guard would have gotten here sooner, none of this would have happened, Mrs. Uebbing said, charging that if the Lagoons area of the river would have been endangered, quicker action would have been taken.

"If they'd get it once — with all their money — they'd (the Coast Guard) hear about it," Mrs. Uebbing said. "It's a shame they don't consider these people down here."

Major said the danger to the valley residents depends "on who's in office downtown."

"We have a mayor who thinks the good Lord will take care of it. The boys in the city ice-breaker wanted to get out earlier," Major said. Major said former mayor John [illegible] had a more effective plan to deal with the ice.

"I've been up here for 25 years and I know this river like a book. When you get a thaw and rain, you'd better get working," Major said.

# Drown City: Mayor (

By GAYLE BLACKBURN
*Staff Correspondent*

VERMILION — Although the Vermilion River Valley was saved from even more flooding damage when an ice jam did not become lodged at the point of the Vermilion Breakwater, the city cannot hope the same will happen in the future, the mayor said.

"We are headed for disaster if the ice cannot flow freely. We cannot depend on Mother Nature every time," Mayor Jim Odom told the city council and concerned area residents during Monday's council meeting.

The flooding which occurred over the past weekend did an undetermined amount of damage to Vermilion businesses and residents. Damage to the area was held to a minimum because the ice floe bypassed the breakwater and turned left at the breakwall, cutting its own path which prevented further flooding and damage.

Odom predicted the situation could become extremely dangerous unless something is done soon about the breakwall.

*"If we don't act soon we will drown the city,"* Odom said.



Area resident and outspoken breakwater opponent George Grossman agreed with the Odom.

"Over the past weekend the city ice-breaking crew saved the Lagoons area from a flood and all of them saw their own homes and businesses flooded like horror dismanagement. The Buffalo district of the U.S. Army Corps of Engineers is directly responsible for the flood damage that did occur between the Liberty Street bridge and the Olympic Club," Grossman said.

The mayor commended all those who helped.

"We had fire and police service on both sides of the river. We are covered as far as the city crews were concerned and we kept the lines of communications open. We were prepared to feed and house people for the evening if necessary."

Odom defended the city's actions in trying to prevent the flood.

"Everything that could be done had been done," he said. "During the two winters that I have served as mayor there has been no property damage, to my knowledge, due to dynamiting in the river." He also emphasized the city ice-breaking boat crew signed waivers because the city provides no protection in case of drowning.

Grossman echoed the mayor's sentiments. "You just couldn't have had people have it better than they did," Grossman said.

"I intend to contact the U.S. Congress and Senate about the renewal of the breakwall before we have a three or four day flood," Odom said.

Odom suggested residents should write to their congressman and the U.S. Army Corp of Engineers to request removal of the breakwater.

George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111
March 5, 1979

Colonel Daniel D. Ludwig
U. S. Army Corps of Engineers
Buffalo District
1776 Niagara St.
Buffalo, New York 14207

Dear Colonel Ludwig:

With a background of five years of observation of ice breakup conditions in the Rocky River Valley and Vermilion Valley, I wish to comment on the flood hazard imposed by the Vermilion Harbor breakwater. I believe that the Vermilion breakwater has a 95% probability of causing a flood with damages in excess of $5 million at least once in ten years.

1. Without the breakwater, the city ice-breaking boat and crew led by Service Director George Phillips, and piloted by Port Authority Chairman Richard Bulan, can prevent ice-jam flooding downstream of the railroad bridges 99% of the time under any ice conditions. They could prevent ice-jam flooding of the Valley Harbor and Riverside Drive areas about 95% of the time if they did not have to cope with the breakwater.

   The city tug "Jaws", complete with crew in overalls, is not a very impressive looking vessel. No one would ever believe that they could clear the river of ice 12"-15" thick--unless they saw the "Jaws" crew do it. Over the past weekend, these four men saved the Lagoons area from a flood--and all four saw their own homes and businesses flooded by Corps mismanagement.

2. The Buffalo District of the Corps is directly responsible for the flood damage that did occur between the Liberty Street bridge and the Olympic Club. The staff of your Cleveland office simply lacks any qualifications to direct ice-breaking operations. The concept of introducing an unqualified layer of command between the city and actual Coast Guard operations is bureaucratic mismanagement at its worst. The Coast Guard is more than qualified to get to a harbor. Local officials, particularly those in Vermilion, are more than qualified to direct the Coast Guard vessel when it arrives.

   When the "Kaw" reached the east end of the breakwater Saturday, it should have remained there and cleared a pool of broken ice to the northeast. Then, the Kaw should have slid in alongside the

breakwater, tied up, and kept its propellors going to blow ice out of the harbor. At daybreak, or possibly even Saturday night, the city crew could have broken ice up to Riverside Drive and prevented the jam at the bridges.

The Corps' decision to send the "Kaw" to Rocky River and Fairport after it had broken a 50' path to the breakwater was a classic example of bad judgment. There were other Coast Guard boats closer to Fairport. Rocky River was already clear. I can concede that the mayors of Rocky River and Lakewood must have political clout but Rocky River let go Saturday, February 24. A small jam remained at the CYC docks but it did not hold back any water. This jam moved out Friday morning, March 2. I personally phoned your Cleveland office about 1:30 PM Friday to advise them that any danger to Rocky River had passed.

3. The field tests of the ice-jamming capabilities of the breakwater have been conducted under optimum rain conditions to date. Twice in the past week, predicted rains did not materialize. When the Vermilion River lets go from slow melt off of snow, an ice-jam forms at Mill Hollow, sticks, and then bypasses water through the park. An inch of rain, perhaps only a half inch, would provide enough pressure to move the Mill Hollow jam downriver. When that jam comes down, it will lock against the breakwater and cause a flood. It won't matter whether the harbor area is clear of ice or not.

4. Ice-jam movements down a river are unpredictable. A jam can be pulled down or pushed down. The jam at Liberty Street was fortuitous because the channel is very deep along McGarvey's dock. Water ran under the jam and pulled ice into Huron Lagoon. Then the jam was pulled downriver in its entirety. The ice spread out. When it hit the track created by the city ice breaker, it went clear to the breakwater before jamming to the bottom in the east channel. A "push" movement would probably have jammed at the Water Works and then jammed again at the breakwater. A "pull" movement of ice can usually be cleared--a "push" jam movement will always be halted by the breakwater. We all saw that occur last year.

5. Flood damages in Vermilion will be increased substantially by a "devil may care" attitude prevalent among some residents and businessmen. One local leader with 66 years on the river feels that one or two days a year of flood problems is not serious. A businessman, noted for his abilities as a raconteur, feels that the biggest flood problem is getting his customers to move up a rung on their bar stools as the waters rise. Many lagoons

residents regarded the events of Sunday, March 4, as the "Ice Jam Festival" which always follows the "Snowmobile Festival".

This attitude will prove costly when a "push" jam locks up against the breakwater. The police warned lagoon residents to evacuate in ample time March 4, but a substantial majority ignored the warning. Perhaps 200 autos that could have easily been moved up to Linwood or the shopping center were not moved. It is very unfashionable, and a show of weakness, to tie up boats or make any preparations for a flood. This "macho" attitude will continue until the flood waters hit again. People who recognize the hazard just put their home up for sale and quietly move out. Only a few lagoons residents realize that their homes were saved by four men who had their own properties flooded. I doubt that anyone from the lagoons has volunteered to help these men with their flood clean-up. And our leading restauranteur is unlikely to lend them his "great staff" with experience in flood clean-up.

This attitude will cause somewhere between $1 million and $2 million of avoidable damages in the next flood. If private insurers handled flood insurance without government backing, they'd "red line" many of the homes and businesses in Vermilion.

Conclusion:

Taking all these factors together, I conclude that the Vermilion Harbor breakwater will cause a flood with $5 million to $10 million in damages on a frequency of about once every ten years. The Corps has its reports on damages from the 1959 and 1969 floods prior to the breakwater. A good flood will take out about 200 automobiles and some 400 boats under existing conditions.

The Corps can continue to field test the ice-jamming characteristics of the breakwater, but only until 1" of rain on top of a snow pack moves water down the river rapidly. This has not happened in six years. At that point, it will be universally recognized that the breakwater has to go.

It is time to address this problem with some reasonable simulation of good engineering practice. The breakwater, which was a 100% unadulterated pork barrel project, was never justified. On August 30, 1978, at a public meeting, I challenged every cost-benefit analysis that the Corps has ever made on the breakwater. I said that there were no tangible benefits resulting from the breakwater. An essentially perfect harbor safety record cannot be improved.

As yet, the Corps has not responded with a revised "benefit" figure. I request that you do this and that you match such benefits against the cost of a flood. If you do this in any reasonable manner, you will initiate action to remove the breakwater at the earliest possible time.

Sincerely yours,

George W. Grossman

cc: All concerned

September 7, 1978

Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207

Attn: Daniel D. Ludwig, P.E.
Colonel, Corps of Engineers
District Engineer

Subject: Vermilion Breakwall Impact Meeting

Gentlemen:

The Army Corps of Engineers meeting was well conducted and interesting. I think it unfortunate that other Vermilion residents, boat owners and business were not represented or did not make some comment.

Since I made impromptu statement at the meeting I decided I should cover my comments in writing.

1. As a Vermilion lagoon resident and as a Lagoon Trustee, I hoped to convey the opinions of a portion of the 130 approximate lagoon residents.

2. The breakwater has fulfilled the intended protection for small boat harbor entrance. Some people object to the difficulty of night visibility, which could be improved.

3. The pollution problem on the beaches definitely exists. The breakwall deflects river flow and contributes to the beach pollution. The source of the pollution is the river itself and EPA efforts should be directed towards improvement. Under storm conditions and acts of God minimum pollution limits can be expected to be exceeded.

4. The breakwall is a contributor in developing ice jam conditions. My personal opinion is that the breakwall itself reduces the formation of ice wind rows. The maintenance of channel depth or increased depth reduces the hazard associated with flooding and ice jamming. This factor was apparently considered by the Corp. when the river channel and harbor entrances were dredged.

Cont.------

5. The lagoon residents believe that the breakwall program has contributed to rapid silting of the Lagoons (primarily Huron and Superior). Our reasoning is very simple and a fact of hydraulic flows. When the river channel was dredged to increase river water flow capacity the secondary flow channel through the Huron and Superior lagoons was reduced in flow and velocity. Drop out of solids as silt is much more rapid with low velocity and the less turbulent flow than exists in the dredged river portion. Our experience indicates 30 years for the first lagoon dredging and only 18 to present time. Dredging should be done now, and would be critical now if the water levels were as low as in 1958 and 1959.

6. Based on samples taken from lagoon, river and lake bottom, it appeared that the organic content was much the same. In this event it is possible that dredgings could be used as fill for Linwood Beach with a beach sand topping.

7. My feeling is that the Lagoon people will cooperate once a program is developed.

I thank you for this opportunity to express some of my thoughts regarding the breakwater impacts.

Very truly,

Calvin C. Blackman

Calvin C. Blackman
5419 Park Dr.
Vermilion, OH 44089

CCB/jw

George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111

August 31, 1978

STATEMENT TO PUBLIC MEETING
ON VERMILION HARBOR

Colonel Daniel D. Ludwig
U. S. Army Corps of Engineers
Buffalo District
1776 Niagara St.
Buffalo, New York 14207

Dear Colonel Ludwig:

The Vermilion Harbor breakwater has been a very poor investment for the public because (1) the benefits predicted for the project have always been greatly overestimated, and (2) the social and environmental costs resulting from the breakwater were not considered prior to construction.

Projected Benefits from Modifying Vermilion Harbor

The first public hearing on the recent changes to Vermilion Harbor was held 33 years ago on May 3, 1945. At that meeting, the mayor stated that the village was unable to contribute anything for changing the harbor. Many of the local citizens were unwilling to pay even a portion of the cost because they did not envision any benefits from changing the harbor. The events of the past five years have proved that this initial local evaluation was accurate.

In 1958, when Congress authorized the breakwater, the Corps estimated annual benefits totaling $107,700 as follows:

| | |
|---|---|
| 50% Net Profit on increased fish catch | $10,100 |
| Savings on losses of fish nets | 9,900 |
| Benefits to recreational boaters | 77,700 |
| Harbor of refuge | 10,000 |

Congress was told that 58% of this $107,700 in benefits were "general benefits to be realized by the nation as a whole", when any effect is obviously purely local. It is of interest that the benefits from "the increased ease and convenience afforded existing navigation" were classified as intangible and not given a monetary value.

In 1971, with plans and cost estimates completed, the Corps stated that the 1956 project costs of $853,000 had inflated 106% to $1,757,000. Consequently, the benefits were also inflated from $107,700 to $229,000 at March, 1971 price levels. The validity of the $229,000 benefit estimate was questioned by the Office of the Chief of Engineers on 20 January, 1972. Thereupon, the Buffalo District revised their estimate of tangible benefits on 16 May, 1972 to the following:

| | |
|---|---|
| Commercial fishing benefits | $ 23,200 |
| Recreational boating benefits | 442,700 |
| Harbor of refuge benefits | 10,000 |
| Total Annual Benefits | $475,900 |

All of these benefit estimates lack credibility. Even the Corps has used the $229,000 annual benefit estimate in the recently issued Section 111 syllabus in lieu of the $475,900 estimate. Apparently, the public, the Corps, and Congress do not expect an accurate accounting when constructing public works with U. S. Treasury funds. They look only for justification of the project. However, the Vermilion breakwater is now assessing us with very real and tangible costs to restore eroded beaches, control pollution, and minimize flood damage. It is time to assess benefits in a way that the public can accept them as credible.

The Actual Benefits to Navigation from the Breakwater

1. Commercial Fishing Tangible Benefits - None. There are no increased fish catches or nets to be saved because of the breakwater. Commercial fishermen had a perfect safety record at the harbor entrance for about 60 years prior to the breakwater. Lake Erie commercial fishermen are skilled and weather-wise. They listen to the weather radio and make harbor before lake conditions become hazardous.

2. Recreational Boating Tangible Benefits - None. Vermilion recreational boaters, for the most part, are also skilled and knowledgeable about the hazards of Lake Erie weather. With just 2' waves on the lake, there are few recreational power boaters to be seen. It is uncomfortable to be out there pitching and rolling. We do see foolhardy boaters hesitate behind the breakwater as they examine oncoming storms before heading home. They frequently will take the gamble unless the Coast Guard herds them back into harbor. Reckless boaters are not aided by a breakwater.

Vermilion docks were filled to capacity long before the breakwater was constructed. Visiting boats were frequently required to raft off because visitor dock space has always been limited. Any claims that the breakwater increases harbor usage and sells more boats, dock rentals, gas or marine supplies are difficult to sustain.

3. Harbor of Refuge Tangible Benefits - None. Vermilion was a harbor of refuge for over 135 years prior to the breakwater. As a summer squall would approach, there was a very orderly and efficient exodus from the lake. Boats swung into line and came straight into harbor. A harbor of refuge is generally considered to be a new harbor like Hammond Bay Harbor on Lake Huron.

4. Intangible Navigation Benefits - Some. Some boaters can claim "the increased ease and convenience afforded existing navigation". However, even this convenience has its price. Stanley Consultants, on page 198 of the impact study, notes increased harbor congestion, restricted visibility, and other navigation problems caused by the breakwater. Stanley also says that these problems "do not constitute hazards to navigation for the knowledgeable, well-prepared, cautious boater." That's all we have ever needed for safety in Vermilion Harbor - knowledgeable, well-prepared, cautious boaters.

Erroneous "Benefit" Accounting in the Section 111 Syllabus

The Corps has employed four tables and several pages of discussion in the Section 111 syllabus to support a new claim that the breakwater has created unanticipated benefits of $39,200 a year by increasing the total size of Vermilion beaches. Even a cursory audit of this very detailed claim of benefits shows that such a claim is outrageous.

1. Lagoons Beach is said to have gained 80,000 cu. yds. of sand while Linwood Beach has lost only 25,000 cu. yds. The source of the extra 55,000 cu. yds. in the Lagoons Beach is not revealed. On page 18 of the syllabus, the Corps estimates that the maintenance of Linwood Beach will require 17,500 cu. yds. of sand every year. At that rate, our losses over the past five years since the breakwater have totaled 87,500 cu. yds. An 87,500 cu. yd. loss to Linwood is balanced somewhat with the amount of sand transferred to the Lagoons, and the amount of sand removed by dredging. The actual loss to Linwood is not 25,000 cu. yds., but 85,000 to 100,000 cu. yds.

2. An annual benefit of $55,600 is claimed for the additional beach created in the Lagoons. Under Corps Reg. EP 1165-2-1, no benefits whatsoever can be allocated for gains in a private beach that is not open to the public. The Lagoons Beach is not open to the public.

3. The total loss of Nakomis Beach was not considered. This beach was 100' wide and 500' long. It was a widely used public beach. Even with the addition of 2,350 cu. yds. of sand in December, 1975, Nakomis Beach has been lost to the breakwater.

4. Vermilion City Beach, a public beach, is now no bigger than it was in 1970 or 1971. The "gains" shown in Fig. 15 of the syllabus do not exist, and the annual monetary gain of $23,200 does not exist. Anyone can see this by visiting Vermilion City Beach.

The Corps has answered our protests about beach erosion with a counter-claim that the breakwater has really increased the size of our beaches. That may be a good political tactic but it is not good engineering or acceptable accounting. The Corps has underestimated the losses to Linwood Beach by a factor of 4 to 25,000 cu. yds. With losses cut in this fashion, it is possible to claim that the breakwater is actually creating beach with a benefit of $39,200 each year. Then the Corps, on page 18 of the syllabus, can say that removal of the breakwater is "inappropriate" because the breakwater has an overall beneficial effect on our beaches.

We have watched a beach 300' wide reduced to almost nothing. We watched the sand move westward into the Lagoons Beach, the river, and the harbor. We watched the dredges haul away our sand. A claim that the breakwater has created beach area in Vermilion is beyond belief, and it certainly does not reflect credit on the Corps.

Conclusion

It is most unfortunate that statutory safeguards for the public were disregarded in the pursuance of harbor modifications that were never needed and are not needed now. We cannot go back and make the Corps and the Vermilion Port Authority comply with these required precautionary procedures. However, the Corps should discard the various "benefit" estimates that have been presented over the past 33 years to justify the breakwater because they are not accurate.

The Corps is now assessing the real costs of repairing damages from the breakwater and preventing further damages, and the Corps must also assess benefits as realities. While we definitely need temporary measures to halt further beach erosion, permanent measures should not taken until a fair and equitable accounting of both costs and benefits is presented.

The benefits to navigation are minimal. If these benefits are stated accurately, it will be obvious that they cannot possibly balance the costs that have resulted from the breakwater.

The breakwater was a very poor investment of public funds. Alternative #1, removal of the breakwater, is the best possible, most beneficial, and least expensive solution for Vermilion Harbor.

Sincerely yours,

George W. Grossman

George W. Grossman

**STANLEY CONSULTANTS**

SUITE 404, 6659 PEARL ROAD
CLEVELAND, OHIO 44130
TELEPHONE : 216/884-7136

March 28, 1978

Colonel Daniel D. Ludwig
District Engineer
Department of the Army
Buffalo District
Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Attention: Mr. John Annony, Project Manager

Gentlemen:

Re: Summary Status Report
Vermilion Harbor Breakwater Impact Study
March 1 to March 31, 1978

During the past month, work efforts on the Vermilion Harbor study have focused on completion of the Section 111 shoreline erosion study. The preliminary draft report on this work element has been finalized and forwarded to your office for review. We are prepared to discuss your comments on this draft at your convenience, and will incorporate them into the final report.

During the past month, the ice cover on the Vermilion River broke up and flowed out into Lake Erie. A visit was made to Vermilion to observe the expected breakup and operation of the Coast Guard icebreaker on March 14 and 15. A copy of the memorandum regarding this field investigation is enclosed. Unfortunately, the ice did not break up at this time, and the icebreaker was delayed near Toledo. Ice breakup and flow from the river actually occurred on March 21, accompanied by some flooding. Several telephone conversations with officials at Vermilion provided the details of the event. The enclosed telephone call report summarizes the significant points.

A letter was recently received from Captain Dennis Dougherty, who is the Commanding Officer of the Coast Guard Icebreaker KAW. He describes in detail the ice breaking problems related to the configuration of the Vermilion Harbor entrance channel. His letter is enclosed.

With the submittal of the Section 111 study, the following work tasks remain:

1. Revisions to the Section 111 draft report.

2. Preparation of a work outline for future investigations regarding mitigation of breakwater impacts.

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Checked by
Filed by RK

3. Participation in the final public meeting at Vermilion scheduled for mid-May.

It is estimated that approximately 95 percent of the work has been completed on the shoreline erosion work element (Contract Modification P00001). An invoice covering work completed through March 31 will be sent under separate cover. The work to be completed under the support requirements, including the recent field visit to Vermilion and preparation of the work outline, will be billed at a later date.

If you have any questions regarding the status of this work, please feel free to call this office.

Sincerely,

STANLEY CONSULTANTS

J. William Allen

J. William Allen
Project Engineer

JWA:jae:7027

Enclosures

cc: Mr. Bayard Weizenecker

# MEMO

To: Files

From: Bill Allen

Date: March 20, 1978

Re. Field Trip to Vermilion to Observe Ice Leaving the River

At the request of the Buffalo District Corps of Engineers, I visited the Vermilion River and Harbor site on Tuesday and Wednesday, March 14 and 15, to observe the expected breakup of the ice cover and subsequent flow from the Vermilion River to the lake. This event was expected due to the prediction of very heavy rainfall in the Vermilion River basin, and the presence of a prolonged period of high temperatures (above 35°). It was also expected that the Coast Guard ice breaker KAW would be in Vermilion on Tuesday to break the ice at the harbor mouth.

On Tuesday, the wind was from the southwest at 15 to 25 knots, and the entire river was frozen with ice in excess of 12 inches thick. The mouth area was also frozen to a distance about one-half mile offshore, where open water could be seen. Water from zero to six inches deep was flowing slowly on top of the ice. There was no apparent movement or breakup of the ice. There was a significant amount of rain Monday night, and the rainfall continued through Tuesday with several heavy periods on Tuesday night. The river was also frozen solid at Mill Hollow, approximately four miles upstream of the harbor mouth. On Wednesday morning, the river had broken up the ice upstream of Mill Hollow, and had formed a new channel outside of the banks at Mill Hollow itself. The water flowed heavily over the park land, and came back within the channel several hundred yards downstream of Mill Hollow. The flow was then confined to the channel, and under the thick ice cover all the way to the harbor mouth. The ice cover in the vicinity of Vermilion Harbor remained unbroken due to its thickness. Several blocks in excess of 16 inches thick were observed at Mill Hollow. The city ice breaker succeeded in clearing a section near the Vermilion Yacht Club about 150 feet long. It was very slow going, however, and they finally abandoned efforts, in spite of additional assistance from a Lorain ice breaker named Bravado. The ice breaker KAW had not appeared as planned, so the mouth of the river remained unbroken. Reports from the Coast Guard indicated that the KAW could be expected late Thursday or Friday. By mid-day Wednesday, the flow at Mill Hollow had subsided, and it became apparent that the ice in Vermilion Harbor was not going to break up immenently. John Annony of the Buffalo District accompanied me on this trip, and we decided that we should not wait any longer for the ice to break up. I returned to Muscatine Wednesday evening.

SC 1602 R1

**MEMO** To: Files

(Continued)

March 20, 1978

Date

Contact with the Vermilion city officials on Friday afternoon revealed that the ice breaker Ojibway had been to Vermilion late Thursday and had opened the mouth area to the open lake. However, this area quickly closed up with ice chunks due to the northerly winds prevailing. The city has now made a second request for assistance from a Coast Guard ice breaker, and is hopefully awaiting an answer. No further natural break up of ice in the Vermilion River has occurred. The city ice breaker has succeeded in opening the area to the harbor mouth. Local people now expect the ice to break when the next heavy rainfall occurs. The Buffalo District has not yet decided whether or not they will request us to visit the Vermilion site a second time when the ice actually goes out.

JWA:st:7027

COPY

1603

**STANLEY CONSULTANTS**
**TELEPHONE CALL REPORT**

Date March 22, 1978 Time ______ M. Job No. 7027

To Mr. George Phillips At Vermilion, Ohio

From Bill Allen, SCI At Muscatine, Iowa

Regarding:

I called Phillips to inquire about the ice situation in Vermilion over the past several days. I have been in frequent contact with Phillips for several weeks, since he is the city official in charge of all ice breaking efforts. Phillips indicated that the ice had indeed left the river on Tuesday, March 21, and significant ice jams and related flooding had occurred in the town.

The ice breakup in the lower Vermilion River channel began on Tuesday morning, and breakup progressed very rapidly. Phillips called the Cleveland Coast Guard around 9:00 a.m. to request assistance by either the KAW or the OJIBWAY in breaking up the harbor mouth and providing a channel for the ice to reach the open water of Lake Erie. The OJIBWAY finally arrived at Vermilion at approximately 6:00, by which time a very large ice jam had formed at the breakwater and extended all the way to McGarvey's Restaurant, which is one-half mile or so upstream. Phillips indicated that during the afternoon, ice rushed down the channel at speeds up to 10 miles per hour, and impacted against the breakwater. The ice could not flow around the breakwater into open Lake Erie water, and therefore a jam rapidly backed up in the river channel. Many of the residents of the Lagoons area were evacuated, and the water rose into the residents' yards. At this time, reports as to the maximum rise of water are conflicting. Whether any significant damage occurred in the Lagoons area is not known.

The OJIBWAY cleared a channel to the open lake during Tuesday evening, and the ice jam at the mouth broke up and moved into the lake. By Wednesday morning, the river was running high (approximately 4 feet on the gage) and fairly clear of ice. The time elapsed from initial breakup until the river was cleared of ice was only a little over 12 hours.

The critical point is of course whether or not the jam would have occurred against the frozen lake ice even if the breakwater had not been in place. It is important to note that the jam occurred in the absence of any assistance from the Coast Guard icebreakers. Since ice flowing down the river would have had no outlet to the open part of the Lake Erie, it is likely that a jam would have occurred at the harbor mouth even without the breakwater. However, it is impossible to tell whether or not the jam would have been more or less stable than the one that occurred on Tuesday. It is true that more flow could have moved out of the river channel by going under the ice, prior to breakwater construction, since the breakwater extends completely to the lake floor. The rise of the water in the Lagoons residential area would be expected to be less without the breakwater.

Further Attention Required? Yes ______ No ______ By ____________________ Date __________

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

MAR 22 1978

Mr. George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111

Dear Mr. Grossman:

We are responding to your February 23, 1978, letter requesting the U.S. Environmental Protection Agency (EPA) to conduct core sampling of Vermilion Harbor sediments and raw water sampling at the water treatment plant in Vermilion, Ohio. Thank you for updating us on your involvement with the U.S. Army Corps of Engineers' breakwall at Vermilion, Ohio and Case No. EBR 77-29, Grossman v. Williams, before the Environmental Board of Review, State of Ohio.

It should be understood that it is the Corps of Engineers' responsibility to conduct the appropriate sediment sampling and analyses for each harbor. (U.S. EPA has assisted the Corps of Engineers under an interagency agreement to perform these tasks but we are reimbursed for our efforts.) However, sediment analyses must be performed in a manner acceptable to U.S. EPA; these procedures must comply with U.S. EPA regulations and guidelines. While our Agency has played an important role in the past in sediment sampling and testing, the Corps of Engineers, with our endorsement, is now beginning to have contractors perform these tasks. It is, and will remain, U.S. EPA's responsibility to classify a harbor's bottom sediments based upon the results obtained from sampling and testing for certain biological, chemical and physical parameters and/or other information about factors affecting the harbor's aquatic ecosystem.

On February 9, 1978, U.S. EPA proposed an amendment to the National Interim Primary Drinking Water Regulations to protect the public health from organic chemical contaminants in drinking water. A copy of these regulations has been enclosed; the period for public comments expires on May 31, 1978. U.S. EPA has determined that the presence of chloroform and other trihalomethanes in drinking water may have an adverse effect on the health of persons. The maximum contaminant level (MCL) of .10 mg/l (100 parts per billion) for total trihalomethanes (TTHM's) is initially applicable only to community water systems serving populations greater than 75,000 and which add a disinfectant to the water in any part of the treatment process. Community water systems serving between 10,000 and 75,000 are only required to monitor for the level of TTHM's in their systems for one

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MAR 22 1978



year; these monitoring requirements become effective 6 months from the date of the promulgation of the proposed amendments - probably sometime this fall. Since Vermilion's water supply system serves approximately 12,000 persons, these latter monitoring requirements would apply to the Vermilion water supply system.

The data obtained from this mandatory monitoring will assist U.S. EPA in assessing the magnitude of TTHM concentrations in systems within the 10,000 to 75,000 population range and in making determinations as to the need and feasibility of revised regulations in that size category. While guidelines currently exist for monitoring TTHM's, no laboratories in Ohio have been certified by U.S. EPA to conduct TTHM testing. Certification of laboratories in the State would be necessary before monitoring requirements become effective.

Your concern for environmental protection is appreciated. Should you wish to express any additional concerns, please contact Mr. Robert Kay at 312/353-2307.

Sincerely yours,

George R. Alexander, Jr.
Regional Administrator

Enclosure now recd

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
Commanding Officer
USCGC KAW (WYTM-61)
1055 East Ninth Street
Cleveland, Ohio 44114

16150
26 February 1978

Stanley Consultants, Inc.
Attention: Mr. J. William Allen
Stanley Building
Muscatine, Iowa 52761

Dear Mr. Allen

1. I received your letter of 3 February 1978, on 14 February, and must apoligize for the tardy reply. A full operational schedule along with the emergency drydocking we are presently undergoing in Sturgeon Bay, Wis., has prevented me from giving your letter the prompt attention it deserves. The opinions expressed below are my own personnal opinions and should in no way be considered as Coast Guard opinions on this matter.

2. There are two distinct icebreaking problem areas in the Vermilion Harbor: the lake approach channel inside the detached breakwater, and the entrance channel upstream from the Vermilion and East Pier lights. I cannot comment on icebreaking problems prior to construction of the breakwater as I have no experience in this area under those conditions.

3. Icebreaking in the lake approach channel up to the Vermilion light can usually be accomplished without undue risk, as long as there is adequate water depth and wind conditions are favorable. Shoaling inside the channel limits to less than a 14 foot depth would restrict or exclude icebreaking operations by a vessel such as the Kaw.

4. Icebreaking in the entrance channel upstream from the Vermilion and East Pier lights is extremely hazardous and cannot safely be conducted under any conditions. The need to make a 90 degree turn to the left to get around the end of the East Pier, in the limited area available with shoal water and stone rip rap present along both piers, creates a situation where the probability of grounding and/or damage exceeds the possibility of a successful entrance into the channel. Once in the channel there is no place to turn around. Backing a vessel with the characteristics of the Kaw out of this channel is very difficult, and again the shallow water and rip rap along the sides of this narrow channel presents unacceptable hazards. This situation can further be complicated by the strong current that is present during the Spring. In addition to making it more difficult to make the turn around the end of the East Pier, the debris, such as tree leaves and other small materials carried in the run-off, rapidly clog the Main Engine cooling water strainers.

16150
26 February 1978

5. If it is necessary to have a vessel such as the Kaw break ice in the entrance channel, I suggest that a sheet pile bulkhead be installed on the inside and around the ends of both piers with dredging up to the bulkheads to provide 14 foot of water. This would eliminate or reduce the hazards associated with icebreaking in the area to acceptable limits.

Sincerely,

D. C. Dougherty

D. C. DOUGHERTY
Commanding Officer
USCGC KAW (WYTM-61)

# Linwood Park Cottage Owners Association

Officers:
President: Dr. Frank Peterka
1st V. P.: Mr. Norman White
2nd V.P. : Dr. George Keidel
Secretary: Mrs. Hazel Cramer
Treasurer: Mrs. Adelle Baker

The purpose of LPCOA shall be the maintaining and preserving of Linwood Park as the outstanding family summer vacation area complete with religion, and sun and shore and sea.

November 9, 1975

Lt. Col. Byron G. Walker
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Lt. Colonel Byron G. Walker;

I am writing this letter on behalf of the Linwood Park Cottage Owners Association, Vermilion, Ohio. Ref: Draft Environmental Impact Statement on Operation and Maintenance of Vermilion Harbor per Notice Federal Register, September 26, 1975, p. 44349.

The Linwood Park Cottage Owners Association (LCOA) represents the leasees who maintain property in the park. Our membership includes people from across the United States. Linwood Park is a tradition. It has been built by 92 years of dedicated work and direction by the directors of Linwood Park Company, LCOA, and the religious council of Linwood. It represents a unique place in our lives and those of thousands of others who came to Linwood to enjoy its sandy beaches and clear waters for a variety of recreational purposes.

Today, however, Linwood is different, and for most of us that difference is for the worst. In 1973 the U.S. Army Corps of Engineers built a breakwater at the mouth of the Vermilion River. We feel that this wall is the cause of "that difference." The reasons for erecting the wall were probably sound at the time, but events of the last few years suggest that any proposed benefits from the wall have been overshadowed by actual results.

As a concerned leasee and President of the LCOA, I feel that you should understand what has happened to our environment since the construction of the breakwall...

I. Acres of our sandy beach have eroded drastically in many areas;

II. Our clear waters have become polluted and unsafe for swimming;

III. The natural flow of the Vermilion River has been diverted away from the center of the lake to our shoreline;

IV. The river channel is narrow and shallower, which hampers our boaters' access to the lake proper; and

V. Our drinking water has become unpalatable.

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Filed by

The net result to our environment since 1973 has been detrimental to our area and caused many adverse feelings among our residents. All of us come to Linwood for a great many reasons; the Corps of Engineers came for a specific one. Yet, if we examine the stated goals of the Corps we find their goals not unlike our own, for each of us are concerned about the environment and its enjoyment by all people.

The stated missions of the Corps are dedicated to accomplishing basic environmental goals which include the following:

I. Be responsible to the full range of social, economic, and other needs in use of water and related resources;

II. Balance environmental quality and development by providing the widest possible range of beneficial uses of the environment without environmental abuse, risk to health or safety, or other unintended, unanticipated, and undesirable consequences;

III. Arrest and abate the degradation and deterioriation of our physical, biological, and cultural environment;

IV. Give environmental values full consideration in decision-making along with technical and economic considerations;

V. Consider a full range of alternatives to solving mans problems and meeting his needs;

VI. Apply non-structural solutions where practical; apply technology creatively and imaginatively with concern for their impacts on environmental quality.

I'm sure you'll agree that the situation warrants a solution...a solution which will be ameanable to all parties concerned. I am confident that through mutual cooperation with your department, the Corps of Engineers, and the LCOA, we can once again enjoy the benefits Linwood Park has to offer its leasees and quests.

I would like to suggest that this letter be included in the final environmental impact report due in December of this year (1975). Please feel free to contact me for any reasons concerning the issues stated above. Thank you for your time and cooperation.

Sincerely yours,

Dr F F Peterka

Dr. F.F. Peterka

cc: Mr. Norman White, First Vice-President
Dr. George Keidel, Second Vice-President
Mrs. Hazel Cramer, Secretary
Mrs. Adelle Baker, Treasurer

NINETY-FOURTH CONGRESS

# Congress of the United States

## House of Representatives

CONSERVATION, ENERGY, AND NATURAL RESOURCES SUBCOMMITTEE
OF THE
COMMITTEE ON GOVERNMENT OPERATIONS
RAYBURN HOUSE OFFICE BUILDING, ROOM B-371-B-C
WASHINGTON, D.C. 20515

October 30, 1975

Lt. General W. C. Gribble, Jr.
Chief of Engineers
Corps of Engineers
Department of the Army
Forrestal Building
Washington, D. C. 20314

Dear General Gribble:

The residents of Vermillion, Ohio, have brought to my attention the fact that in 1973 the Corps of Engineers constructed a breakwater in the harbor of Vermillion. This was apparently done in the face of public protest, and with assurances by the Corps that no undesirable environmental effects would follow.

It now appears that the breakwater has caused a number of undesirable results--contaminating the municipal water supply, polluting swimming areas, eroding and destroying municipal beaches and creating navigation hazards.

Under these circumstances we would like you to inform us whether these problems have been brought to your attention, have you investigated these problems, have you identified solutions to the problems, have you discussed solutions with the citizens of Vermillion, Ohio, was an environmental impact statement or assessment made prior to the construction of the breakwater, was the impact of the breakwater monitored after the construction was completed?

If any of the foregoing questions are answered in the negative, please provide a full explanation of the reasons for such failure.

In addition, please inform me of the Corps' plans for dealing with the unfortunate situation at Vermillion.

Your prompt response to this letter will be appreciated.

With best regards,

Sincerely,

William S. Moorhead

WILLIAM S. MOORHEAD
Chairman

ODNR

Ohio Department of Natural Resources

Fountain Square · Columbus, Ohio 43224 · (614) 466-3770

September 10, 1975

Robert C. Gorman
Certified Public Accountant
215 Court Street
Elyria, Ohio 44035

Dear Mr. Gorman:

Governor Rhodes has asked me to respond to your letter of August 27, 1975 concerning the Vermilion River breakwater, which was constructed by the Corps of Engineers at the request of the constituents from the City of Vermilion.

As a result of a meeting held in Vermilion on April 22, 1975, the Corps of Engineers has initiated a study to determine the possible adverse effects from construction of the breakwater. Please be advised that the Ohio Department of Natural Resources is strongly interested in this study, and will review and evaluate the results of the study when it is completed.

Your interest and concern in this matter are appreciated.

Sincerely,

ROBERT W. TEATER
Director

RWT/sl

cc: Corps of Engineers, Buffalo District

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# RUTLEDGE EQUIPMENT COMPANY

FLOOD LIGHTING EQUIPMENT • GASOLINE AND OIL EQUIPMENT

TELEPHONE 261-1415
AREA CODE 412

334 BOULEVARD OF THE ALLIES
PITTSBURGH, PA 15222

August 27, 1975

Lt. General William C. Gribble, JR
Office of Chief of Engineers
Dept. of the Army
Washington, D.C. 20314

SUBJECT: Lake Breakwater, Vermillion, Ohio

Dear General Gribble:

This writer has become cognizant of Mr. George Grossmans letter of August 18, 1975 directed to you, relative to the Corps of Engineers construction of the Vermillion harbor breakwater which has actually become a threat to a large percentage of the Vermillion population.

In addition to being a boat harbor, the lagoon area itself includes the residences of approxamately 75-100 families. The value of these residences totals to several million dollars.

A blockage of flow caused by the breakwall at the mouth of the Vermillion River provides enough back-up during the winter season, as a result of ice jams and etc., that all of these residences are threatened by flood each and every year, if there is enough ice build-up on the river and at the mouth of the river. Fortunately for the last two years it has not provided such a build-up. It was very close this past winter (Jan.-Feb., 1975). The past two winters have been basically open seasons as far as cold weather and freezing were concerned. Prior years have been sufficiently cold for a sufficient length of time to provide ice build-up, even without the Breakwall to threaten these residences. With the Breakwall, the build-up would almost insure the total flooding and damage of a good portion, if not All of these above mentioned residences.

This writer is personally interested in the elimination of this breakwall, or the total revision of it, in as much as he is a resident of Linwood Park, whose swimming beach area is just to the east of the breakwall.

George Grossman has provided you with arial photographs of the breakwall, the river mouth, and the adjacent areas; which greatly illustrates the total movement of our Linwood Park beach area to the west wichis a direct result of the breakwall blockage of the normal wave action from the north west, on our length of beach. As Permitts, the northeast storms and any northeast turbulance tomove the sand from the beach in a westwardly direction, which has not only greatly reduced the depth of our Linwood park beach, but which has provided such a build-up as f front of sand in front of the lagoon area, it actually washes over the east pier and provided sand bars in the river mouth itself, which of course, creats a blockage of travel in and out of the river. It has been necessary, in the short period of

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TELEPHONE: 261 - 1415
AREA CODE 412

334 BOULEVARD OF THE ALLIES
PITTSBURGH, PA. 15222



time that the breakwall has existed, to actually dredge the river on two or three occasions in order to keep the channel open. The underwater sand at the lake edge has been totally washed away from the eastern end of the Linwood beach area. The beach depth has been reduced in the short time the breakwall has been in existance by approximately 50-60%. When you loose 50-60% of your beach area in a 2 year period, as a direct result of a Corps of Engineers "Goof-up", it should follow that the Corps of Engineers should be directly responsible for restroation of the origional situation, and elimination of the cause, of course, with intervening monetary damages which could be considerable; or by the Federal government, which created this situation in the first place.

I personally feel that the most irritating thing about this situation is the fact that various residents of Linwood Park, Vermillion, Ohio, met with representatives from the Corps of Engineers at the time construction was going on. We expressed the direct conviction that the construction of this wall would cause the exact effects that have taken place. We were assured by the Corps of Engineers representives that we were totally wrong in that none of this action would take place.

As a result of the Corps Construction, we have left beach and are in the process of heading toward "No Beach". We now have dirty, poluted water being trapped along the beach line due to the fact that the overflow of the river and the Lake has been diverted to provide flow of the river sediment, garbage, and etc. onto and along our Linwood Beach.

The Writer wishes to request your opinion in view of the above information, and in view of Mr. George Grossman's letter, How long it will take the Corps to come to the same conclusion that we have and in turn, how long it will take the Corps to modify or remove the breakwall that has caused these problems.

In as much as the writer is personally a resident of Pittsburgh, Pa., and a summer vacationist in Linwood Park, Vermillion, Ohio; he is providing a sopy of this letter and a copy of Mr. Grossman's letter to Honerable Charles A. Mosher, Pennsylvania Senators Honerable Hugh Scott and the Honerable Richard Schweiker and to Congressman William S. Moorehead.

We wish to thank you for your consideration of the above stated requests. The wrtier feels that this is a serious problem and that the speediest of replies and considered action is of the utmost.

Yours very truly,

J. W. Rutledge

JWR:car

City of Vermilion

OFFICE OF THE MAYOR

JACK ARMSTRONG, MAYOR

736 Main Street
P.O. Box 317
Vermilion, Ohio 44089
Phone: 967-5517 or 967-6777

May 7, 1975

The Honorable Charles A. Mosher
U.S. House of Representatives
2442 Rayburn Building
Washington, D.C.

Dear Congressman Mosher:

As you are undoubtedly aware, we have a tentative meeting scheduled with Colonel Hughes of the Corps of Engineers at your office on June 16.

Since the date for the meeting was established some time ago and no definite time set, it is my feeling that we should perhaps correspond as to details and intent.

We are most interested in attempting to obtain funding to either extend or protect our water intake. As you know, the intake lies within our new breakwall, which, by the way, <u>is</u> doing the job for which it was intended. However, the concern regarding our water system is very real and something must be done. We have considered the possibility of a crib to protect the intake. It is my hope that Colonel Hughes's knowledge will help us decide which way to go with this problem.

I will be waiting to hear from you concerning the meeting, and any assistance you could render would be most appreciated.

Sincerely yours,

Jack R. Armstrong

Jack R. Armstrong, Mayor
City of Vermilion, Ohio

JRA:mel
copy: Colonel Bernard Hughes ✓

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City of Vermilion

OFFICE OF THE MAYOR

JACK ARMSTRONG, MAYOR

736 Main Street
P.O. Box 317
Vermilion, Ohio 44089
Phone: 967-5517 or 967-6777

April 11, 1975

Colonel Bernard Hughes
U.S. Army Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Hughes:

On April 22, 1975, at 7:30 P.M., we will be holding a "Town Meeting" at the City Hall to discuss the public concern regarding our breakwall.

We feel this will give the citizens an opportunity to express their concern; and in turn receive intelligent answers to their inquiries. Many citizens in Vermilion are either new to our area or have forgotten the original reasoning and intent for the construction of the breakwall.

The meeting will be attended by representatives from the Ohio Department of Natural Resources and a representative from Congressman Mosher's office. It would be most helpful and greatly appreciated if you or a representative from the Corps could attend.

Thanking you for your continued interest, I remain,

Sincerely yours,

Jack R. Armstrong

Jack R. Armstrong, Mayor

JRA:mel

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Vermilion Harbor
Vermilion, Ohio

Impact Study of the
Detached Breakwater

APPENDIX B

<u>The Special Impact Study of Ice Jam Flooding, Vermilion Harbor, Ohio</u>
Tetra Tech, Inc., July 1980

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

TC 3319-02
JULY 1980

TETRA TECH

# FINAL REPORT

## SPECIAL IMPACT STUDY
## ICE JAM FLOODING
## VERMILION HARBOR, OHIO

**A STUDY OF MODIFICATIONS TO THE EXISTING PROJECT TO PERMIT EFFECTIVE ICEBREAKING OPERATIONS**

PREPARED FOR

UNITED STATES ARMY
CORPS OF ENGINEERS
BUFFALO DISTRICT

## EXECUTIVE SUMMARY


This report evaluates three harbor design options that seek to al /iate the threat of flooding caused by ice jam formation on the Vermilion River, Ohio. These alternatives include:

1) Additional channel dredging to accomodate U.S. Coast Guard ice breaking vessels;
2) Creation of a 200-foot wide gap in the Vermilion Harbor offshore breakwater to allow ice floes to pass from the river channel directly into the lake; additional dredging is also required to allow Coast Guard ice-breaking operations;
3) Complete removal of the offshore breakwater;
4) No Action.

The Corps of Engineers states in the Scope of Work for this contract that "the state-of-the-art does not permit quantification of the impact or the damages attributable to the detached breakwater" (as regards flooding caused by ice jam formation). For this reason, an economic analysis comparing the benefits and costs of each option was not included in this study.

The locations of ice jam formation on the Vermilion River have been well documented both before and after the construction of the offshore breakwater in 1973. Since 1973, no change in jam location has occurred upstream of the harbor entrance piers. Ice windrows that previously formed across the harbor pier ends prior to the 1973 construction now form at the offshore breakwater, a distance of 300 feet lakeward of the pre-breakwater position.

This physical separation of ice windrows from the river outflow at the pier ends results in a decrease in probability of ice jam formation at the river mouth. Scientists from the U.S. Army Cold Regions Research and Engineering Laboratory have expressed the opinion that the offshore breakwater serves a beneficial role in preventing ice jam flooding at the Vermilion Harbor entrance.

U.S. Coast Guard ice-breaking vessels have historically performed ice jam clearance in the Vermilion Harbor entrance. The construction of the breakwater in 1973 has created additional navigational difficulty for these vessels by requiring more complex maneuvering in order to enter the harbor. This difficulty to date, however, has not prohibited the entrance of ice breaking vessels. It is acknowledged, however, that a higher level of risk is associated with harbor entry at present than that of the pre-breakwater period when a "straight-in" vessel approach to the harbor was used. The 110-foot Coast Guard vessel ARUNDEL entered the harbor to break ice in February, 1980, thus, indicating that the harbor entrance allows ice-breaking operations for the class of Coast Guard vessel in operation at the time of design and construction of the breakwater. However, the Coast Guard has recently introduced a new vessel class that will serve as the principal icebreaker for Lake Erie. This new vessel will have a length of 140 feet and will require 15 feet of water depth to safely navigate (this is 3 feet greater than the presently authorized 12-foot channel in Vermilion Harbor). It is the purpose of this study to determine which of the four alternatives mentioned previously should be implemented to decrease the threat and severity of future ice jamming for the following conditions:

Design Condition #1: Ice breaking by the new, 140-foot ice breaker that requires 15 feet of water depth (3 feet more than that which presently exists) to navigate in Vermilion Harbor. Creation of additional channel depth over the presently authoriz d 12-foot limit will require Congressional authorization.

Design Condition #2: Ice breaking performed by the 110-foot ice breaker that has been traditionally used at Vermilion and for which the present harbor project was designed, authorized, and constructed.

The criteria with which the various harbor entrance modification alternatives were judged are as follows:

- o Ability to reduce ice jam potential;
- o Navigational safety during ice-free periods;
- o Engineering feasibility (construction and maintenance);
- o Effect on beach stability along adjacent shores;

- o Environmental impact;
- o Cost

Recommendation For Design Condition #1 (140-foot Ice Breaker):

For the new, 140-foot ice breaking vessel, the recommended alternative to minimize the threat of ice jam flooding at the Vermilion Harbor entrance is the dredging of a 15-foot deep channel in the east harbor entrance to provide sufficient depth for the new vessel to maneuver. The total cost of creating this new channel is $186,700. This figure represents the additional dredge cost over the presently authorized maintenance of the twelve foot entrance channel.

The alternative calling for deepening the west approach channel to 15 feet to accomodate transit of the 140-footer was rejected due to the very high cost associated with rock removal at that location. In addition, ice breaking through the west channel is not needed if ice breaker operations in the east channel are successful.

The two alternatives that require the removal of all or part of the offshore breakwater were both rejected for Design Condition #1 due to the following weaknesses:

1) Lack of evidence that these options would indeed lower the probability of ice jam occurrence;
2) Negative impact that breakwater modification or removal would have on safe navigation during ice-free periods;
3) High cost.

The recommended alternative for Design Condition #1 is designed to allow easier passage of the new 140-foot Coast Guard ice-breaker through the windrow zone at the harbor entrance. Also, the additional dredging of the east channel to a depth of -15 feet (LWD) will allow a greater depth over which ice floes can pass before grounding on the lake bed. This should provide sufficient depth for the river discharge to pass beneath the ice field at this location.

A ranking of the alternatives for Design Condition #1 was performed based upon the criteria specified above. The "No Action" alternative was judged to be just slightly less desirable than the recommended alternative of deepening the east transit channel. The option calling for complete breakwater removal was judged to be least desirable of all the alternatives considered.

Recommendation for Design Condition #2 (110-foot Ice Breaker):

Based on the history of ice breaking operations at Vermilion since the breakwater construction of 1973, it is judged that "No Action" is appropriate for the case in which the 110-foot ice breaker is available for service. It has been evident on several occasions since 1973 that prudent and timely action by the Coast Guard's 110-foot vessel can yield adequate and effective ice breaking operations at Vermilion. The alternatives that require structural modification of the breakwater have been rejected in the belief that such action will increase the threat of ice jamming at the harbor entrance.

This evaluation has implicitely assumed that Coast Guard icebreaker assistance will be available for immediate deployment to Vermilion should the need arise. The Coast Guard has maintained that the rapid response of an ice breaker to an ice jam emergency at Vermilion may not be possible to achieve due to other commitments and responsibilities throughout Lake Erie. This fact emphasizes the need for the city of Vermilion to undertake an assessment of its local ice breaking capability in the event that timely action must be taken without the benefit of Coast Guard icebreaker assistance.

AD-A125 562 VERMILION HARBOR OHIO CONDITION SURVEY REPOR' STUDY OF THE IMPACT OF THE..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT M C FABOS ET AL. SEP 82 3/3

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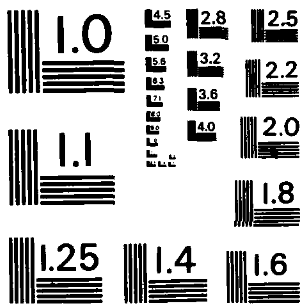


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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## 1.0 INTRODUCTION

### 1.1 STUDY PURPOSE

The city of Vermilion, Ohio, has experienced a history of flooding caused by ice jam blockage of the Vermilion River during the spring ice breakup period. The construction of a detached, offshore breakwater in 1973 has caused some concern among Vermilion residents that this structure may create an increased potential for future ice jam flood damage. While no ice jam flooding has occurred that can be positively attributed to the construction of the breakwater, some local residents have expressed a fear that a future winter season exhibiting those conditions that cause major ice jam formation will lead to damage by upland flooding induced principally by the offshore breakwater.

Traditionally, the ice breaking needs of Vermilion have been served primarily by the U.S. Coast Guard. The vessel used principally was 110-feet in length, requiring twelve feet of water depth in which to navigate safely. The present harbor as authorized by the Federal government can accomodate this vessel.

Recently, the Coast Guard instituted the use of a new class of ice breaker for Lake Erie. This new vessel is 140-feet in length and requires 15 feet of water in which to safely operate. Based on the authorized channel depth of 12 feet that currently is in effect at Vermilion, the new vessel cannot be expected to enter Vermilion Harbor unless the lake level is greater than three feet above the low water datum.

The purpose of this study is to evaluate the feasibility, effect, cost and expected performance of three harbor entrance modification alternatives that have been considered by the U.S. Army, Corps of Engineers, Buffalo District, to decrease the potential for ice jam flooding. This analysis will address two design conditions:

<u>Design Condition #1</u>: Ice breaking performed by the new, 140-foot Coast Guard vessel that required deeper water depths than that now existing at Vermilion.

Design Condition #2: Ice breaking operations performed by the 110-foot Coast Guard Vessel that traditionally performed adequately within the harbor.

The three structural alternatives to be considered are as follows:

1. Deepening of the harbor approach channel to accommodate Coast Guard ice breaking vessels.

2. Removal of a central portion of the breakwater and appropriate channel deepening so that Coast Guard icebreaker operations will be less hazardous.

3. Complete removal of the breakwater.

In addition, the "No Action" alternative (Alternative #4) is also considered.

## 1.2 DESCRIPTION OF THE STUDY AREA

Vermilion Harbor is located at the mouth of the Vermilion River on the south shore of Lake Erie, about 37 miles west of Cleveland. The location and principal elements of Vermilion Harbor are presented in Figure 1.2.1.

The harbor consists of east and west approach channels from the lake, four artificial lagoons, and the lower 3,600 feet of the Vermilion River. The harbor supports the use of many recreational and some fishing vessels. Presently, approximately 100,000 yearly trips are undertaken by small boat operators from the twelve yacht clubs and marinas that serve the harbor (Stanley Consultants, 1978).

The latest structural modification to Vermilion Harbor occurred in 1973 when an 864-foot long cellular sheet-pile breakwater was constructed at a distance of 300 feet from the northern ends of the harbor piers. Figure 1.2.2 shows the design of the sheet-pile breakwater cells, as well as the design of the harbor piers that were first constructed in the late 1830s.

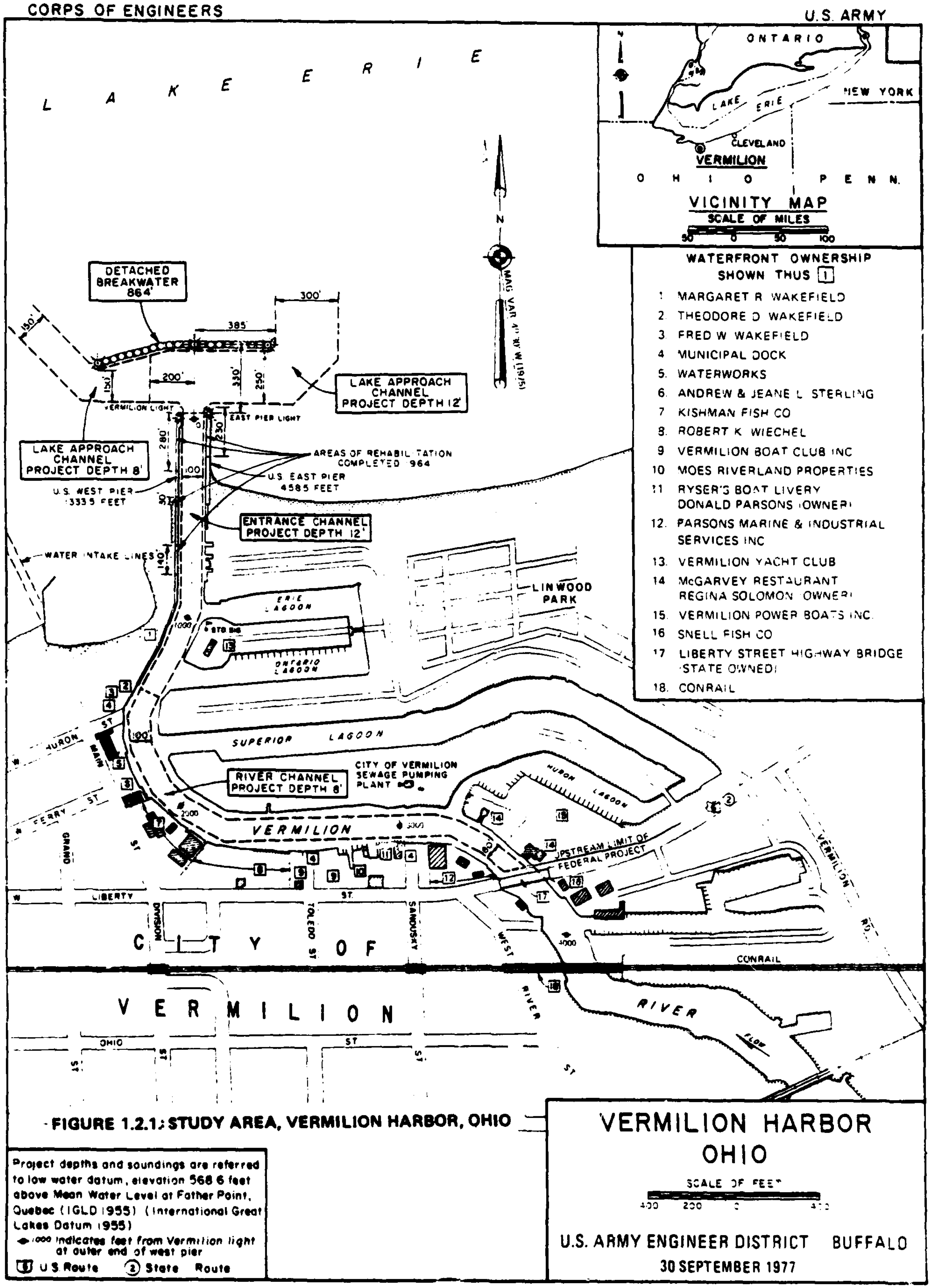
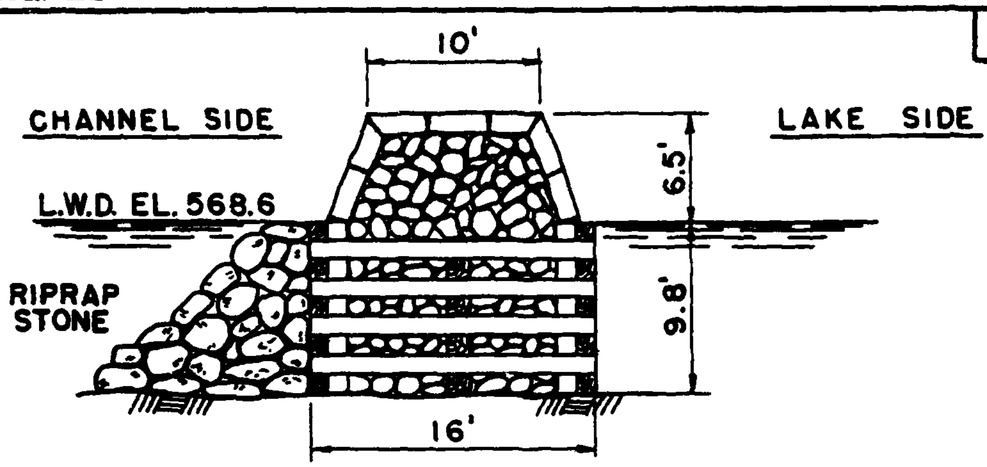



FIGURE 1.2.1: STUDY AREA, VERMILION HARBOR, OHIO

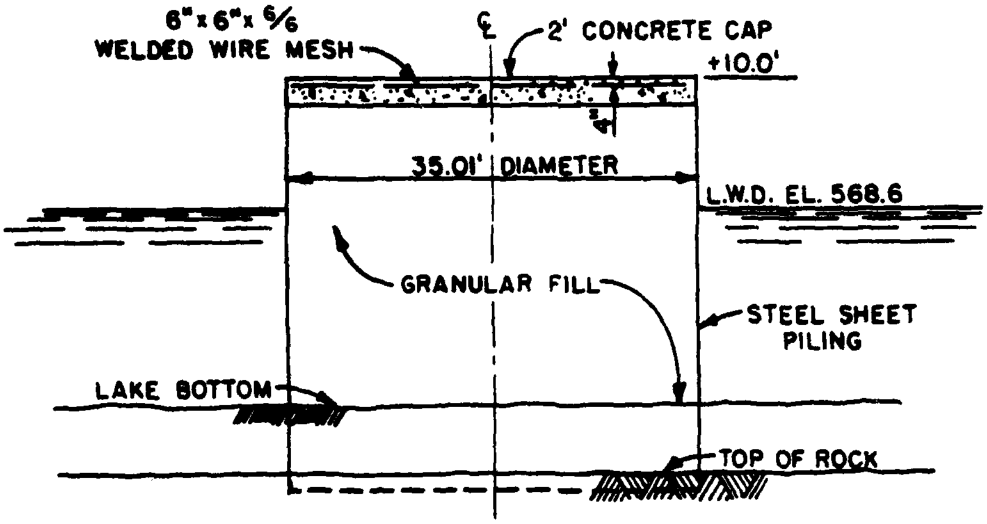
CORPS OF ENGINEERS | U. S. ARMY




SECTION OF EAST PIER

WEST PIER SIMILAR BUT OPPOSITE HAND
(BUILT 1836 - 1839, REBUILT 1906 - 1914)

REHABILITATION OF 450 FEET OF WEST PIER AND 230 FEET OF EAST PIER INITIATED IN JUNE 1964 AND COMPLETED IN OCTOBER 1964. (TOP ELEVATION RAISED TO 6.5 FEET ABOVE L.W.D. AND RIPRAP STONE PLACED ON LAKE SIDE.)




DETACHED BREAKWATER
(BUILT 1973)

VERMILION HARBOR, OHIO

U.S. ARMY ENGINEER DISTRICT BUFFALO
30 SEPTEMBER 1977

FIGURE 1.2.2: DESIGN OF PIER AND BREAKWATER STRUCTURES, VERMILION HARBOR

One of the purposes of the offshore breakwater was to provide a sheltered harbor entrance during heavy weather periods and a reduction of the wave and surge action within the harbor.

## 1.3 DESCRIPTION OF PROBLEM

As stated earlier, there is concern among some Vermilion residents that the offshore breakwater constructed in 1973 will contribute to future flood damage due to its possible effect on ice jam initiation and subsequent jam strength. This perceived threat is occasioned by the interpretation that ice, which would normally flow out into the lake, will be blocked at the breakwater. The ice jam thus formed will cause a water level increase upstream which may cause damage to upland properties. Certain residents believe that the ice jam potential at the harbor mouth has been further aggravated by the creation of an entrance channel that may cause difficult navigation problems for large ice breaking vessels. While the Coast Guard vessels KAW and ARUNDEL have transited this channel successfully in the past, severe ice jamming and windrow formation tend to tax the capabilities of these vessels. It has recently been determined that the Coast Guard will replace these 110-foot cutters with a larger, more efficient ice breaking vessel. The Coast Guard was queried to define the role that the new vessel will play in Vermilion ice problems and this information has been incorporated into the ice jam mitigation alternatives considered in this report. The results of pertinent discussions with Coast Guard personnel during the execution of this study are provided in Section 8.2 of this report.

In summary, this study addresses three specific structural alternatives and the "no action" alternative with regard to their relative influence on ice jam flood prevention for two design conditions. Design Condition #1 utilizes the new, 140-foot vessel that requires a deeper water depth for safe navigation than that now in existence at Vermilion. Design Condition #2 uses the traditional 110-foot ice breaking vessel.

Since the construction of the offshore breakwater in 1973, no ice jam flooding events have been attributed to the offshore breakwater.

Prior to breakwater construction, ice jams formed at the river mouth and, in several instances, Coast Guard ice breakers were stopped by ice more than 1,000 feet from the entrance to the harbor (Potter, 1975). While this evidence cannot be conclusively used to state that the offshore breakwater reduces the ice jam flooding potential at the harbor entrance, it tends to reinforce the opinion expressed by the U.S. Army Cold Regions Research and Engineering Laboratory (Frankenstein, 1979) that the ability of the breakwater to restrict the onshore movement of ice windrows into the river channel bounded by the parallel jetties serves as an "asset to Vermilion for reducing ice jam flooding at the entrance to the lake".

## 2.0 BACKGROUND

### 2.1 ICE-INDUCED FLOODING HISTORY

Note: In order to facilitate understanding of the discussions that follow, a few terms associated with ice and ice jams are contained in the Appendix of this report.

The threat of ice jam formation and subsequent flooding on the Vermilion River has been a source of concern for the citizens of Vermilion for many years. The maximum threat of ice jam flooding occurs during th January-March break-up period when warming temperatures and/or rainfall cause melting and weakening of the river ice. A number of factors inflı the severity of the ice jam potential on the Vermilion River. These include:

1. Water Level--The lower the level in the lake/river, the smaller the flow cross-section beneath the ice sheet.
2. Winter Temperature--The colder and more prolonged the winter, the thicker the ice sheet.
3. Thaw Temperature--Warmer temperatures yield greater river discharge.
4. River Discharge.

Local information has been gathered concerning the location of major ice jams on the Vermilion River. Figure 2.1.1 shows the locations of jams on the river as they propagate downstream with periodic stops at particular locations associated, primarily, with constricted channel geometry. Historically, following initial jam formation at the Norfolk and Western Railroad Bridge, the jam will advance downstream undergoing periods of stall at the locations shown and subsequent advance (once the pressure of the backwater causes internal failure of the jam). The time required for a jam to move from initial formation to the lake is approximately 6-10 hours. The ice jams shown in Figure 2.1.1 have historically formed on the Vermilion River both before and after the construction of the offshore breakwater.

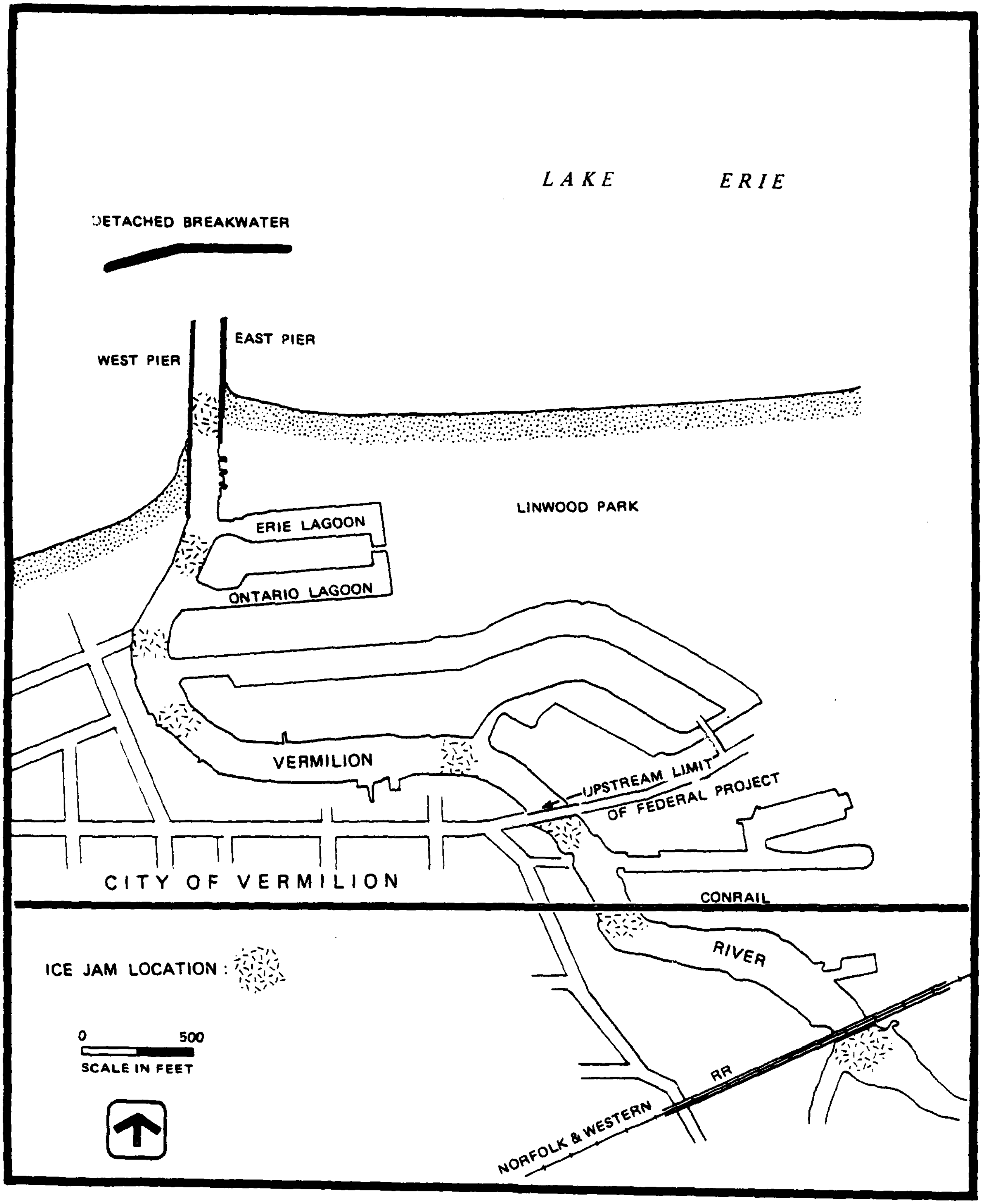



FIGURE 2.1.1: ICE JAM LOCATIONS, VERMILION HARBOR

## 2.2 PRE- AND POST-BREAKWATER ICE CONDITIONS

In the Vermilion River channel, ice forms as a function of water temperature and water motion. Stanley Consultants (1978) has presented an analysis that sought to describe the effect of the offshore breakwater on current flow within the river. This computer modelling effort, aimed at a variety of discharge and lake level conditions, concluded that the breakwater had an insignificant effect on the river flow velocity. Based on this observation, it was further concluded that no change in the nature or extent of ice formation within the river has developed due to the placement of the offshore breakwater. Ice borings were taken in February, 1977, to determine the ice thickness attained at various river locations. This data, published by Stanley Consultants, is presented in Figure 2.2.1. It can be seen that the ice thickness varies between 1.5 and 2 feet throughout the channel area.

Unlike the river channel, the area adjacent to the harbor jetties has undergone major change in regards to ice formation since the construction of the offshore breakwater. Figure 2.2.2 shows the general location of the pack and windrow ice both before and after breakwater construction. While the strong, thick ice blockage was previously across the northern ends of the harbor piers, the addition of the breakwater has served to displace the windrow ice 300-500 feet to the east and west of the jetties. The breakwater creates an offshore projection that catches pack ice moving from the west with the prevailing winds. A windrow ice plug is created in the west approach channel of the harbor thus preventing closure of the river mouth by windrow ice. Since the construction of the breakwater, the west channel has been completely closed by surface ice on at least two occasions (Stanley Consultants, 1978). When ice conditions and wind direction combine appropriately, pack ice may also close the eastern approach channel although this is a less frequent occurrence. Accumulation of pack ice at both entrances simultaneously has occurred.

During the break-up period, the area south of the breakwater is either unfrozen or covered with sheet ice. While no serious ice jam flooding has been reported near the river mouth since the breakwater was constructed in

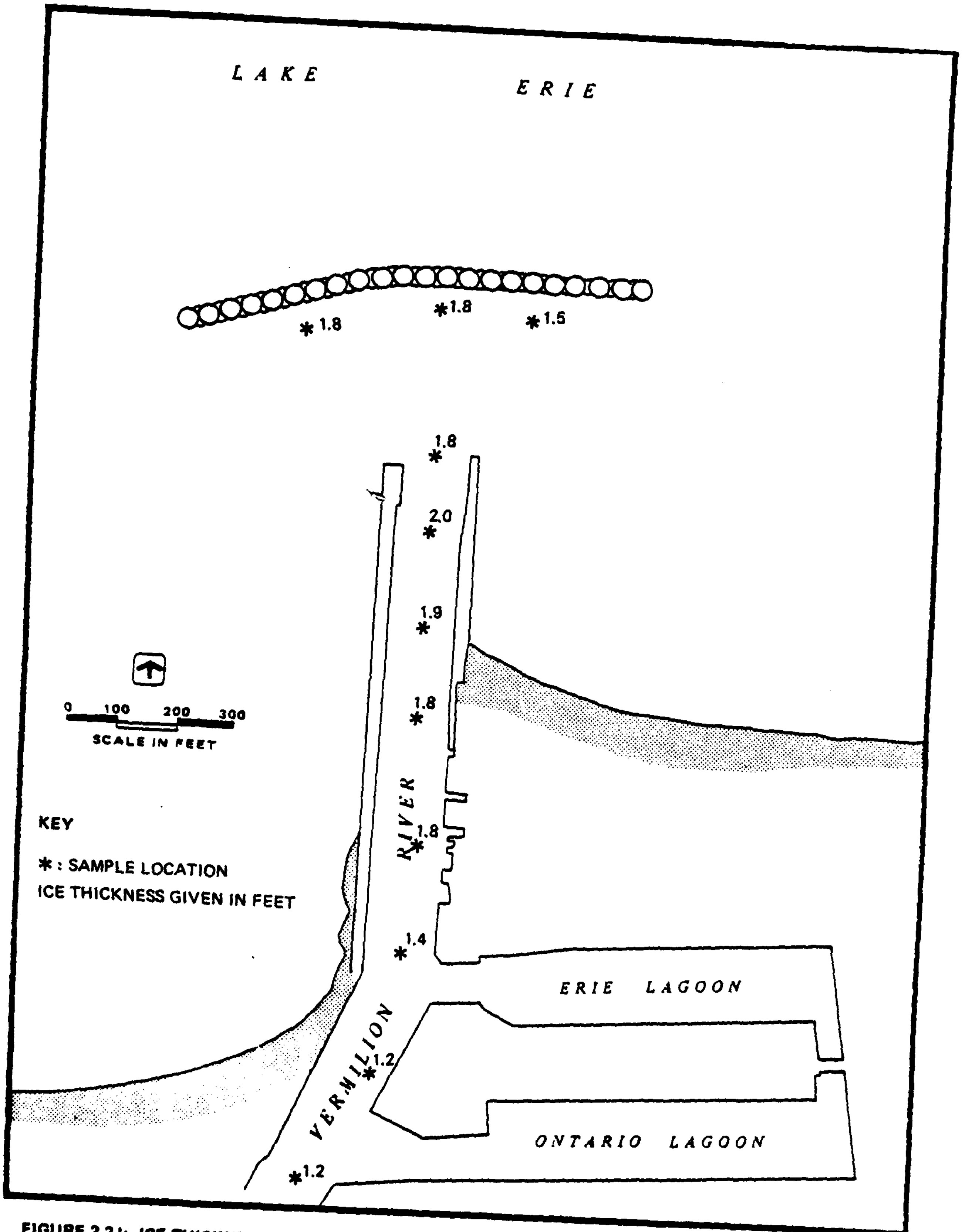
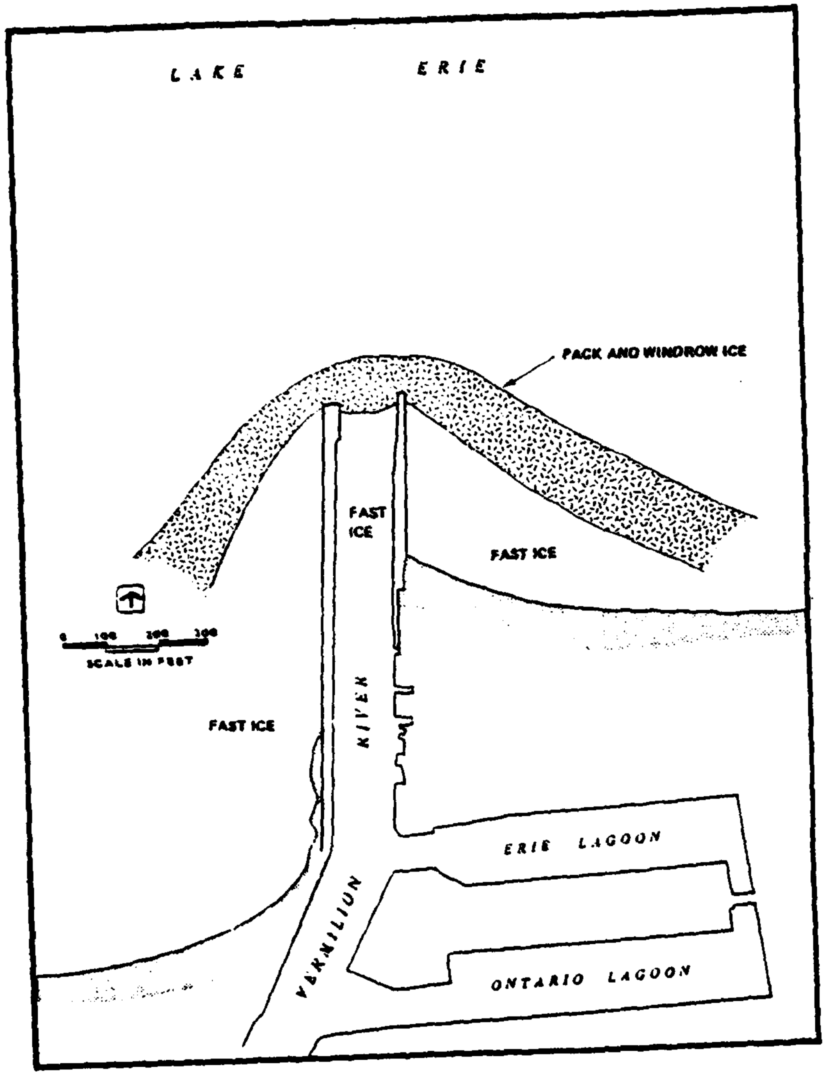
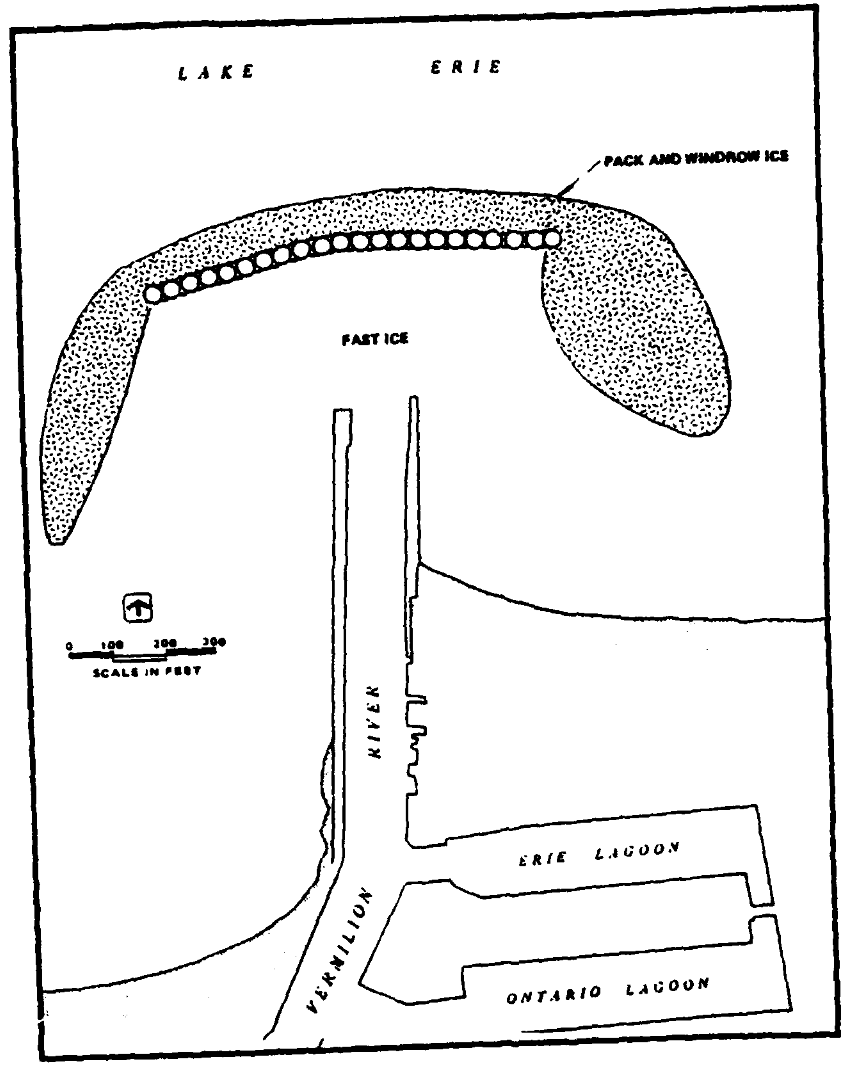



FIGURE 2.2J: ICE THICKNESS MAP, VERMILION HARBOR (from Stanley Consultants, 1978)




A. PRE–BREAKWATER




B. POST–BREAKWATER

FIGURE 2.2.2: ICE LOCATION, VERMILION HARBOR

1973, some citizens are concerned by the hypothesized increase in jam po-potential caused by the "blocking" effect of both the breakwater and the windrows that form to the east and west of the structure.

The position taken by the U.S. Army Cold Regions Research and Engineering Laboratory scientists (see Ref. 1, Section 8.2) is that the offshore break-water has created a more protected environment at Vermilion Harbor in terms of ice jam prevention at the entrance. The position paper states, "...the detached breakwater is an asset to Vermilion for reducing ice jam flooding at the entrance to the lake. It certainly reduces water levels due to ice re-lated floods by creating the windrow further into the lake and allowing a longer diffusion front of the water from the river into the lake. But ice jams and related flooding though unrelated to the detached breakwater may occur again on the river upstream of the mouth and the city should not feel that the break-water has solved the upstream ice jam problem, but it has reduced the down-stream ice jam threat". These conclusions would appear to be supported by the previous occurrence of ice jam flooding events prior to the breakwater con-struction. These events are documented in the Flood Plain Information Report, Vermilion, Ohio (U.S. Army Corps of Engineers, 1968).

## 2.3 ICE-JAM MITIGATION

When a major ice jam forms, the blockage must be freed to alleviate the potential flooding due to the water level rise upstream from the jam. If no action is taken, one can only hope that the force of the backwater pressure will break the jam prior to the backwater elevation achieving a destructive flood stage. In the past, ice jams on the Vermilion River have been success-fully broken using explosives and small city-owned shallow draft ice breaking vessels occasionally assisted by U.S. Coast Guard ice breaking operations. This has been the case both before and after the breakwater construction in 1973.

Prior to 1973, the Coast Guard icebreaker KAW was called upon to break the thick, windrow ice at the river mouth to provide a path along which river water and ice could flow into the lake. The smaller ice breaking vessels

that are operated by the City are not capable of breaking the thicker ice of the windrow zone. As mentioned earlier, the offshore breakwater now acts as a barrier to drifting ice such that windrows pile up to the west, east and north of the structure leaving the harbor entrance south of the breakwater either unfrozen or covered with sheet ice.

Presently, ice moving out of the river mouth normally tends to impact the breakwater structure and, depending on winds and river discharge, either backs up or flows to the east. In either of these cases, it is important to provide a path through the windrow zone for the passage of river ice and water to the lake. Since 1973, the Coast Guard ice breaker has been able to provide an outlet through this area prior to the initiation of ice movement down-river.

To provide safer entrance conditions at Vermilion for pleasure craft and commercial fishing boats, the Rivers and Harbors Act of 1958 initially authorized construction of overlapping "arrowhead" breakwaters at a distance of about 500 feet lakeward of the outer end of the east pier. A model study of the proposed breakwater system was completed in 1969. The study, limited to investigating the effects of various structures on wave action, showed that the arrowhead breakwater plan did not provide sufficient protection for full use of the harbor.

Based strictly on wave protection considerations, a 700-foot long structure was then proposed that would be installed perpendicular to the channel centerline at a distance of 200 feet from the outer end of the east pier. Subsequent discussions with the U.S. Coast Guard and the Vermilion Port Authority indicated that other factors in addition to wave action should be considered in the placement of the breakwater. The Port Authority felt that additional width was required at the harbor entrance to "provide a larger channel for the winter ice to escape safely into the lake and to permit the Coast Guard to come into the harbor to break up the ice jams" (U.S. Army, Corps of Engineers, 1971). When the Coast Guard expressed this same concern, the Corps of Engineers modified the design plan to increase the breakwater length to 864 feet and locate the structure 300 feet north of the west pier (or 100 feet further lakeward than the alignment recommended by the model study).

During this design period, a transit channel oriented in a northeast-southwest direction was proposed for the east entrance of the harbor. Dredging activities during construction showed the existance of exposed bedrock that required removal in order to provide the necessary 12-foot water depth within this channel. Due to the extremely high cost of such excavation, the U.S. Army Corps of Engineers, Buffalo District, in conjunction with the U.S. Coast Guard, and the Vermilion Port Authority decided to reorient the east channel to a north-south alignment,thus avoiding the area of exposed bedrock. This decision was subsequently approved by the U.S. Army, Corps of Engineers, North Central Division.

In a letter dated 27 October 1970, the Commander, Ninth Coast Guard District, stated the rather tenuous ice breaking agreement that existed at that time regarding the mobilization of a Coast Guard icebreaker to Vermilion:

> "(In order to dispatch an icebreaker to Vermilion)...
> ...First, there must be a clearly defined threat of flooding...
> ...Second, a Coast Guard vessel must be available...
> ...Third, the replacement program for our 110-foot harbor class tugs has not yet been developed and may not provide for a vessel with characteristics which permit icebreaking in Vermilion Harbor".

The Coast Guard icebreaking fleet on Lake Erie is presently in a state of change. The Coast Guard reports that the 110-foot class vessels used in the past (and for which the Vermilion Harbor project was authorized and constructed) will be replaced with a larger, faster, more efficient vessel class. This should provide more effective ice breaking capability in the commercial shipping lanes which is the primary objective of the Coast Guard ice breaking program. The larger 140-foot class icebreaker has a 12.5 foot draft and requires a 15-foot water depth for safe icebreaking operation (U.S. Coast Guard, personal communication). The Vermilion Harbor channel has been federally authorized to be maintained at a depth of twelve feet relative to the low water datum of 568.6 feet IGLD. Thus, if the channel is not deepened, the vessel could not break ice at Vermilion unless a relatively high lake level (571.6 feet, IGLD) existed. Based on historical lake level information, the 571.6 foot lake level has existed throughout the January-March period only

five times in the last sixty years. Thus, unless the entrance channel to Vermilion is deepened beyond the 12-foot authorized depth, it is expected that the new 140-foot Coast Guard ice breaking vessel cannot be used routinely. The Corps of Engineers has indicated that any additional channel deepening would require Congressional authorization.

The citizens of Vermilion have relied on other ice breaking vessels in the past. These include a small City icebreaker, steel hulled fishing boats, and a 60-foot tugboat from Lorain. These vessels are all limited to operations in areas where the ice thickness is less than about one foot. In general, the critical windrow section at the Vermilion harbor entrance exceeds this thickness and, in the absence of a suitable ice breaking vessel, explosives have also been used successfully in the past to clear this critical region.

## 3.0 CRITERIA

Despite the possible need to improve the ice breaking capability at Vermilion Harbor, certain aspects of the offshore breakwater's performance should not be sacrificed to obtain this goal. The criteria with which the ice jam mitigation plan should be judged are as follows:

1. Navigational Safety During Ice-Free Periods
   As a popular boating center on Lake Erie, Vermilion Harbor should not jeopardize its standing by adopting a solution intended to mitigate ice jam flooding at the expense of safe navigation unless the adverse effects attributed to the breakwater approach or outweigh the beneficial effects that the breakwater supplies to recreational navigation. As a federally supported "Harbor of Refuge", the safe passage of recreational and commercial fishing craft into Vermilion Harbor in violent storm periods is of special concern.

2. Engineering Feasibility
   All aspects associated with specific flood prevention plans (channel deepening, ice breaker operations) must be feasible to construct and maintain.

3. Effect on Beach Stability Along Adjacent Shores
   The chosen plan shall not have a negative impact on the beach stability either to the east or west of the harbor entrance.

4. Environmental Impact
   Any alternative plan should not cause significant detrimental effect on water quality, aquatic biota, recreational activities, aesthetics, social and community well-being.

5. Cost
   The construction and maintenance costs of the project shall not exceed the damage anticipated from ice jam flooding induced by

the breakwater. To the present time, no ice jam flooding has been attributed strictly to the offshore breakwater. Earlier studies (Stanley Consultants, 1978) concluded that the engineering "state-of-the-art" does not allow the quantification of breakwater-induced flood damage. Therefore, this study is limited to cost estimates for each alternative evaluated. A benefit/cost analysis is believed to be beyond the "state-of-the-art" and is not included within the scope of this study.

## 6. Responsibility

A determination of responsibilities for implementation and maintenance of each alternative has not been evaluated in this report. This must be performed by the government agencies involved and the Vermilion Port Authority, the local sponsor for the harbor project. In addition, the additional channel deepening below the twelve foot authorized depth (below Low Water Datum), if recommended by the Corps of Engineers, must be authorized by the U.S. Congress.

## 4.0 EVALUATION OF ALTERNATIVES FOR DESIGN CONDITION #1: 140-FOOT COAST GUARD VESSEL

### 4.1 ALTERNATIVE 1: DEEPENING OF EXISTING CHANNELS

This alternative involves deepening of the entrance channels lakeward of the piers. This would provide improvement in the following ways:

1. A depth of 15 feet would be available during the ice jam season for the new 140-foot Coast Guard icebreaker to navigate safely.

2. The additional depth allows greater river discharge beneath the ice sheet at the harbor entrance. This should serve to alleviate, to some degree, the flooding potential even if ice breaking operations are not performed.

In deepening the existing channel to allow passage of the new 140-foot ice breaker, both lake level fluctuations and sedimentation must be considered to determine the quantity to be excavated to create and maintain the new channel depth. The existing channel is maintained at -12 feet below the Low Water Datum of 568.6 feet (IGLD).

During periods when the lake level is higher than the Low Water Datum, Vermilion Harbor depths exceed twelve feet. Thus, if the lake level exceeded +3 feet relative to the low water datum [or 568.6' + 3' = 571.6' (IGLD)] no dredging would be required to provide a 15-foot water depth. The occurrence of such a high lake level is relatively rare--especially in the January-March period when the lake tends to achieve its yearly low level due to lack of precipitation and river discharge. Records indicate that a January-March lake level of 571.6' IGLD has occurred only five times in the past sixty years. Since 1950, the lake level during the January-March period has exceeded 570.6' IGLD (+2' LWD) 47% of the time and has exceeded 569.6' IGLD (+1' LWD) 83% of the time. To assure 15 feet of water, three feet of channel deepening is required. An alternative would be to deepen the channel only two additional

feet with the understanding that at the time that ice breaker operation is desired, an additional one foot of water may be provided by the water level above the low water datum (since, on the average, this level should exist eight of every ten years).

Additionally, sedimentation within the channel must be expected. Thus, any channel deepening should exhibit a measure of "advanced maintenance" to compensate for the shoaling that is expected between dredge operations.

Given these conditions, it is recommended that the channel should be dredged an additional three feet, or to -15 feet (LWD) (553.6' IGLD). This will provide at least one foot of advance maintenance dredging if the water level is 569.6' IGLD which has been the case during the critical January-March period over 80% of the time since 1950.

The Commander, Ninth Coast Guard District, and the Engineering Officer, Coast Guard Icebreaker BRISTOL BAY (a 140-foot vessel) have been consulted to establish an understanding of preferred ice breaking routes at the Vermilion Harbor entrance. Two possible routes shown in Figure 4.1.1 are proposed that will provide relief from ice blockage by the windrows. The first route (Route I) would require passage of the vessel through the entrance from the east to the west along a 100-foot wide channel which allows over 30 feet of clearance on each side of a 140-foot icebreaker (beam = 37.5 feet). No right-angle turns into the river channel would be required to provide a route of ice passage to the lake, thus limiting additonal dredging to a portion of the entrance channel immediately south of the offshore breakwater. It is the opinion of the Coast Guard that this ice breaking route would be safe and effective in opening the windrow zones during periods when upstream water pressure was low. However, if the action of ice breaking at the entrance would cause a rapid release of flow out the river channel, the ice breaking vessel could be forced to the north and might be in danger of colliding with the breakwater structure. Therefore, this icebreaker route is not considered safe or attractive under all conditions.

Close inspection of previous survey data shows the existence of bedrock at

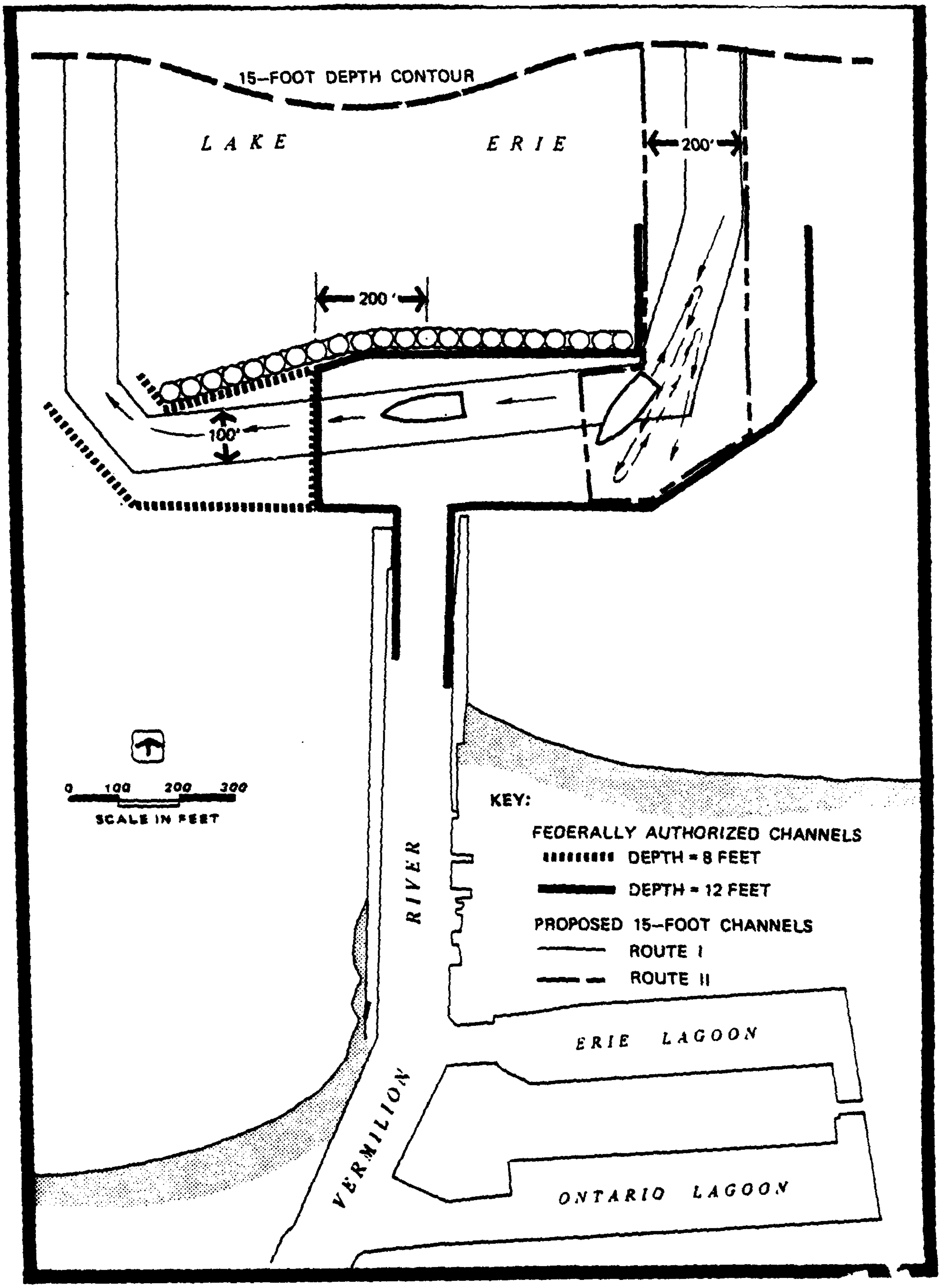



FIGURE 4.I.I: ALTERNATIVE I : ICE BREAKER ROUTES

*about the -10 foot (LWD) depths in the western transit channel*, thus necessitating expensive blasting operations and rock dredging to deepen that section of the channel if Route I was chosen. Because of this reason, another option has been identified and is designated "Route II" in Figure 4.1.1. This would call for the deepening of only the eastern side of the harbor entrance where no bedrock removal is required. Thus, only the eastern windrow zone would be breached to allow the river flow of water and ice to reach the lake. The flow cross-section of the river mouth has been computed and has been found to be smaller than that existing across the eastern exit. For this reason, even if the western channel was totally blocked by windrow ice, the water flowing between the piers could be easily accommodated in an open channel on the eastern side. The option of opening only the eastern channel is predicated on the safe operation of the Coast Guard ice breaker within this 200-foot-wide channel. Although the maneuverability of the new 140-foot class icebreaker has not been well defined, it if feasible the the BRISTOL BAY could be backed out of an opened ice field without damage to the ship's *steering gear or propulsion system. If this is indeed the case*, the forward motion with subsequent backing would be preferable in terms of safety to providing a turning basin to the south of the breakwater. This ice breaking procedure is shown in Figure 4.1.1. Again, because this second option does not require expensive rock excavation and removal, it is preferable to the first option that requires a complete crossing of the harbor entrance.

Although the Coast Guard does not presently object to the eastern access, the true proof of acceptance will only occur following the first attempt at this ice breaking procedure.

### 4.1.1 Effect on Ice Formation

The deeper water within the proposed 15-foot channel should allow additional water to flow under the ice cover relative to the existing 12 foot channel. Although ice windrows will still form over the channel, deeper water depths should lessen the extent of ice contact with the channel bottom and, thereby, weaken the windrow over the channel.

### 4.1.2 Effect on Navigation

Deepening the harbor entrance would not significantly change the ease with which the existing vessel traffic could navigate in the vicinity of the harbor piers and breakwater. This region is currently well protected from heavy wave action.

### 4.1.3 Effect on Stability of Adjacent Shores

Deepening of the channel at the Vermilion Harbor entrance will sustain this area's present performance as a sediment impoundment basin. Periodic dredging will be required to maintain adequate channel depths. At that time, if chemical analysis shows that the dredge spoil is composed of material suitable for beach use (as prescribed by Environmental Protection Agency Regulations), it can be transferred to beaches requiring replenishment. If, however, the sediment is deemed harmful (due to contamination by river-borne pollutants), it would be transferred to an appropriate disposal site and, thereby, lost for placement back to the nearshore and beach zones. Unless an equal quantity of suitable sand is placed on adjacent shores, erosion of those shores is expected. Sediment dredged in 1979 was deemed "unsuitable" for beach replenishment.

### 4.1.4 Costs

Estimates have been made of the volumes of dredging and associated costs based on 1980 prices for the two icebreaker routes shown in Figure 4.1.1. The unit cost for recent entrance channel dredging operation is presented in Table 4.1.

TABLE 4.1: ENTRANCE CHANNEL MAINTENANCE DREDGING HISTORY POST-BREAKWATER (OCTOBER 1973), VERMILION, OHIO

| | COST | VOLUME DREDGED (c.y.) | COST | UNIT COST | ESCALATED 1980 COST | DISPOSAL |
|---|---|---|---|---|---|---|
| 1. | Sept-Dec, 1973 | 25,700 | $187,900 | $7.30 | $12.20 | Land & Deepwater |
| 2. | June, 1974 | 5,900 | $ 24,000 | $4.10 | $ 6.80 | Beach on west side of harbor |
| 3. | February, 1975 | 3,000 | $ 10,300 | $3.40 | $ 5.40 | Beach on west side of harbor |
| 4. | Nov-Dec, 1975 | 10,850 | $ 53,200 | $4.90 | $ 7.20 | Nakomis Beach, east of harbor & deepwater disposal |
| 5. | 1978 | 3,496 | $ 18,000 | $5.15 | $ 6.23 | Deepwater disposal |
| 6. | Oct-Nov, 1979 | 23,000 | $147,200 | $6.40 | $ 7.30 | Deepwater disposal |

Based on the guidance of the Corps of Engineers, Buffalo District, the unit cost of sand dredging is $7/cubic yard, while that for rock removal is estimated to be $30/cubic yard. Deep water disposal of these materials is assumed in this cost analysis. If the dredged rock and sediment can be used for shore protection or beach replenishment purposes, its value is greatly enhanced. However the acceptability of the dredged sediments for such purposes is considered to be remote by the Buffalo District, Corps of Engineers.

TABLE 4.2: INITIAL DREDGING COSTS*, CHANNEL DEEPENING+

ROUTE I COSTS

| | Volume (c.y.) | Unit Cost | Cost |
|---|---|---|---|
| Sediment: | 19,800 | $ 7 | $138,500 |
| Rock: | 16,400 | $30 | 492,000 |
| Mobilization/Demobilization: | | | 10,000 |
| Subtotal | | | $640,000 |
| Contingency (15%) | | | 96,100 |
| Subtotal | | | $736,700 |
| Engineering/Design (20%) | | | 147,300 |
| Supervision/Inspection (6%) | | | 44,200 |
| Overhead (5.6%) | | | 41,300 |
| Subtotal | | | $969,500 |
| Navigation Aids | | | 15,000 |
| TOTAL | | | $984,500 |

ROUTE II COSTS

| | Volume (c.y.) | Unit Cost | Cost |
|---|---|---|---|
| Sediment: | 15,500 | $ 7 | $108,500 |
| Mobilization/Demobilization | | | 5,000 |
| Subtotal | | | $113,500 |
| Contingency (15%) | | | 17,000 |
| Subtotal | | | $130,500 |
| Engineering/Design (20%) | | | 26,100 |
| Supervision/Inspection (6% ) | | | 7,800 |
| Overhead (5.6%) | | | 7,300 |
| Subtotal | | | $171,700 |
| Navigation Aids | | | 15,000 |
| TOTAL | | | $186,700 |

* 1980 Costs
\+ Dredge costs are in addition to that required for authorized 12-foot channel.

The construction cost of the Route II channel is about 20% of the cost for Route I. Additionally, Route II appears to be the ice breaking route that would cause the least risk to the Coast Guard ice breaking vessel. By avoiding the area to the south of the breakwater, the potential vessel damage caused by the rapid release of river water would be minimized. Route II includes the premise that the 140-foot Coast Guard icebreaker can effectively conduct operations by entering the east channel and thence reverse propulsion for backing to deeper lake waters via the ice broken route. It is apparent that the degree of operational acceptance of Route II will be contingent upon experience of the first and successive field operations.

### 4.1.5 Future Maintenance Requirements

The maintenance dredging required since 1973 to achieve a twelve-foot channel takes place approximately every two years. It is assumed that this time interval for maintenance dredging would be required for a fifteen-foot depth.

The maintenance activities undertaken at Vermilion since the breakwater construction of 1973 have been presented previously in Table 4.1 Exact estimates of expected sediment removal at the Vermilion Harbor Entrance are difficult because some of the past dredging activities (particularly those of 1973 and 1979) have included the removal of material from both the outer harbor and the river channel. Quantities dredged separately in 1973 and 1979 were approximately 25,000 cubic yards, an amount that is from two to eight times greater than the individual dredge quantities of the intervening period. Based on this information, it appears that dredging of the upland river channel takes place at 5 or 6 year intervals. By ignoring the years of up-river channel dredging, an estimate of 5800 cubic yards of annual dredge spoil is computed for the 1974-1978 period. The expected dredge volume of 5800 cubic yards represents that material that will require removal on an average yearly basis. Because the proposed location of the channel is not changed, and the existing channel is presently an effective littoral impoundment zone, deepening the channel depth from -12 feet to -15 feet (LWD) is not expected to affect this average annual dredge quantity. In addition

to this average annual dredge quantity within the Harbor, shoaling of the proposed 15-foot channel to the north of the breakwater is expected. The additional dredge requirement for that portion of the channel located to the north of the present channel limits is estimated to be 1,650 cubic yards/year. The computations that established these volumes are contained within the Appendix. Estimates of the annual volume to be dredged if Route II is constructed are presented in Table 4.3. It is anticipated that the dredged volume will slowly decrease with time as updrift supplies of sand dwindle due to ongoing shore protection efforts.

TABLE 4.3: ANTICIPATED ANNUAL MAINTENANCE DREDGING COSTS*, ALTERNATIVE 1

| | | |
|---|---|---|
| Volume (cubic yards) | | $ 7,450 |
| Unit Cost | | $ 7/c.y. |
| | Subtotal | 52,200 |
| Mobilization | | 5,000 |
| | Subtotal | $57,200 |
| Contingency (15%) | | 8,600 |
| | Subtotal | $65,800 |
| Engineering/Design (20%) | | 13,200 |
| Supervision/Inspection (6%) | | 3,900 |
| Overhead (5.6%) | | 3,700 |
| | TOTAL | $86,600 |

*1980 costs

### 4.1.6 Summary

Deepening the entrance channel to Vermilion Harbor would create an environment which would lessen the probability of ice jamming at the entrance and would also provide adequate depth for the navigation of the Coast Guard's new 140-foot icebreaker. The additional depth provided under the ice sheet would facilitate the discharge of river flows into the lake and would lessen the possibility of a jam contacting the lake bed. Two icebreaker routes have been evaluated and costs associated with each have been derived. Any channel deepening at the west harbor entrance will require rock blasting and excavation. The high expense and disruptive nature of this alternative tends to

make this an unattractive option. Also, the Coast Guard has expressed concern for icebreaker safety in the area south of the breakwater. Under certain conditions passage of the vessel on an east-west course through this zone is considered hazardous. The Coast Guard has indicated that the more acceptable icebreaker route is contained completely within the east harbor entrance. Breaking a path through the windrows on only the east side should provide a route of ice and water escape from the river to the lake. Because the area to the south of the offshore breakwater is an effective sediment impoundment zone, deepening the channel an additional three feet will have no effect on river sedimentation or the volume of sediment lost from adjacent shores. However, as in the present situation, periodic maintenance dredging will be required. If the dredge spoil exhibits acceptable physical characteristics, it may be transferred to the adjacent beaches. If the spoil is contaminated by river pollutants (the more probable condition according to the Corps of Engineers), it could prove to be unacceptable for beach nourishment. If this is the case, the beaches adjacent to the harbor must be supplied with sand from other sources in order to mitigate erosion.

During dredging operations, the water at the river mouth is expected to experience increased turbidity. This condition should be essentially the same as for past maintenance dredging operations.

## 4.2 ALTERNATIVE 2: BREACH DETACHED BREAKWATER AND DEEPEN APPROPRIATE CHANNEL AREAS

Alternative 2 involves breaching of the central portion of the breakwater and aligning the entrance channel with the central opening. This plan would allow for a more direct route of ice flow from the inner harbor to the lake if the windrow ice that would form at the breach were removed by icebreaking procedures. Such procedures, if performed by the new 140-foot class Coast Guard vessel, would require additional dredging of a portion of the entrance channel to a depth of -15 feet LWD (553.6 feet, IGLD). Figure 4.2.1 illustrates the entrance configuration, probable ice conditions, and the icebreaker's route through the 200-foot wide breach. The 150-foot wide channel having a depth of 15 feet would terminate just inside the north ends of the Harbor jetties. It is not considered feasible for the 140-foot icebreaker

to safely navigate into the upper river channel so no channel has been provided for that activity.

### 4.2.1 Effect on Ice Formation

The breakwater breach combined with the effect of the deepend channel entrance could allow drifting ice floes to penetrate the gap and ground in the area south of the breakwater (see Figure 4.2.1). Windrow formation would subsequently proceed to promote a relatively wide windrow zone at the breakwater gap. If the winter weather was mild, it seems plausible that the ice formation at the gap would be removed by the flow of river water since the deeper water at the entrance would probably not allow strong attachment of the windrow ice to the lake bottom at this location. If, however, the winter weather was severe and the thaw period was quick and extreme, the river discharge may not be able to displace the windrow ice and ice breaking operations would be required to allow the river ice to move into the lake. If the ice breaker was not able to respond to the City's request, and other ice breaking options were not exercised, then it seems conceivable that (in an especially severe ice jam scenario) the breakwater gap could allow the windrow ice to approach the river mouth with a resultant decrease of the cross-sectional area of the outflow. This condition would be approaching that which prevailed prior to construction of the offshore breakwater.

### 4.2.2 Effect on Wave Climate/Navigation

During the design of the offshore breakwater, wave height criteria were established to ensure satisfactory navigation and mooring conditions in the lee of the proposed breakwater. These criteria were as follows:

> (Under the most severe storm conditions)
> ...maximum wave heights should not exceed 2.5 feet at the entrance to the harbor (at the pier ends) or 1.5 feet in the river channel at the entrances to the lagoons. (Brasfield, 1970).

To date, it is believed that these criteria have been met and the general impression gained from all interests interviewed is that the breakwater has provided wave protection for Vermilion Harbor in an exceptional manner.

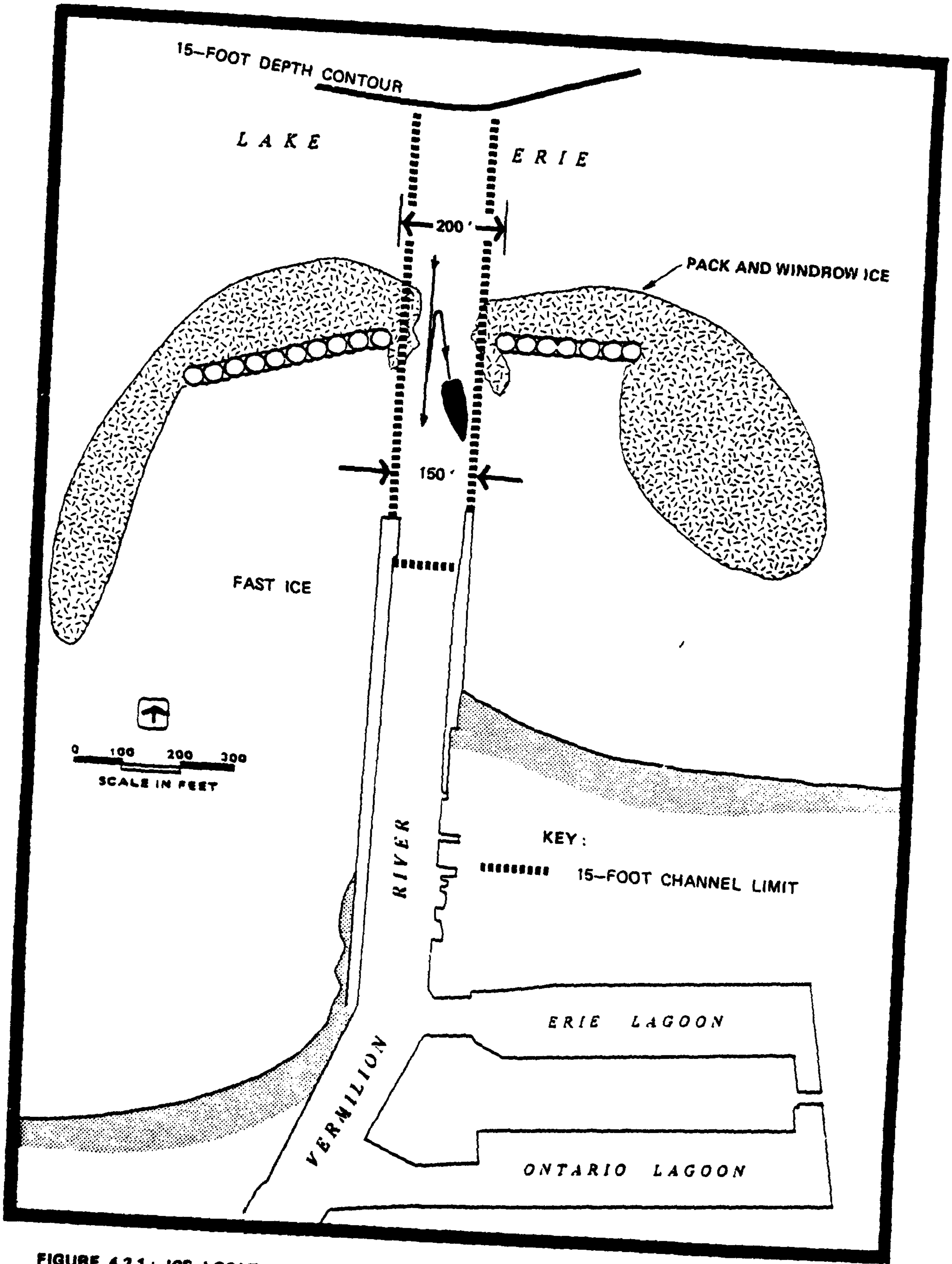



FIGURE 4.2.1: ICE LOCATION AND ICEBREAKER ROUTE – ALTERNATIVE 2

Removal of the central portion of the breakwater would have a detrimental impact on the safety of navigation at the harbor entrance and in the adjacent river channel. Obviously, removal of the structural protection provided by the breakwater will cause an increase in the present levels of wave energy existant in the vicinity of the piers. Three wave analyses have been performed to approximate conditions at the harbor during periods of expected northwest, north, and northeast wave episodes. The design wave characteristics for the Vermilion site were taken from the Waterways Experiment Station Technical Report H-76-1, <u>Design Wave Information for the Great Lakes</u>, Report 1, Lake Erie (Resio & Vincent, 1976).

Wave data taken from this report are presented in Table 4.4 as a function of recurrence interval, season, and direction of approach. The design wave chosen for the analyses exhibited a 20-year recurrence interval. It is important to note the disparity between the fall-winter wave climate and that of the spring-summer season. The design wave heights nearly double during the rough weather period relative to the fair weather spring and summer months. Because the vast majority of Vermilion boating activity takes place during the summer months, the design wave value chosen is the maximum expected value for the spring-summer period. The values chosen for the wave analyses are noted in Table 4.4.

TABLE 4.4: DESIGN WAVE STATISTICS, VERMILION, OHIO
(from "Design Wave Information for the Great Lakes", Resio & Vincent, 1976)

| | DIRECTION OF APPROACH | | | |
|---|---|---|---|---|
| Recurrence Interval (Years) | NORTHEAST | NORTH | NORTHWEST | |
| | | WINTER | | |
| 10 | 7.9 Feet | 9.8 | 9.3 | |
| 20 | 8.5 | 11.2 | 10.5 | |
| 50 | 9.5 | 12.5 | 11.8 | |
| | | SPRING | | |
| 10 | 4.6 | 3.0 | 5.2 | |
| 20 | 5.9 | 3.9 | 6.2 | |
| 50 | 7.9 | 5.6 | 7.5 | |
| Recurrence Interval (Years) | NORTHEAST | NORTH | NORTHWEST | |
| | | SUMMER | | |
| 10 | 4.9 | 5.2 | 5.2 | |
| 20 | $\boxed{5.3}$ | $\boxed{6.2}$ | $\boxed{6.2}$ | ← DESIGN VALUE USED |
| 50 | 7.5 | 7.9 | 7.5 | |
| | | FALL | | |
| 10 | 9.2 | 8.5 | 9.3 | |
| 20 | 11.2 | 9.5 | 9.3 | |
| 50 | 14.[illegible] | 10.5 | 10.3 | |

For the wave analysis of the breakwater gap, the incident wave heights were modified to allow for refraction (via Snell's Law) and shoaling. Thus, a factor related to these two phenomena ($K_r \cdot K_s$) was used to alter the design incident wave height to the wave height at the breakwater structure. A wave diffraction study using standard coastal engineering techniques was then performed to interpret the nature of wave modification by the structure. Information concerning the wave heights within the harbor were a result of these computations.

CASE I: <u>INCIDENT WAVES FROM THE NORTHWEST</u>

The design wave height chosen for this study was the significant* wave height exhibiting a 20-year recurrence interval for the case of northwest wave approach.

$H_o$ = deepwater wave height = 6.2 feet

$T_D$ = design wave period = 6.1 seconds

(*Resio & Vincent*, 1976)

The combined refraction and shoaling factors ($K_r \cdot K_s$) are computed to be 0.97 at the breakwater that is positioned in a water depth of 12.5 feet (LWD). Thus, at the structure, the design wave parameters are as follows:

$H_D$ = design wave height at structure = 6.2 (0.97) = 6.0 feet

$T_D$ = 6.1 seconds

The diffraction study was performed and the results of this exercise are presented in Figure 4.2.2.1. For this case, wave diffraction was considered both at the proposed harbor breach and also at the western end of the breakwater represented by Point "A" in Figure 4.2.2.1. The curved lines in the figure represent lines of constant wave height at the time of design wave occurrence. In the area between the breakwater and the piers, there occurs

* Average height of highest one-third waves.

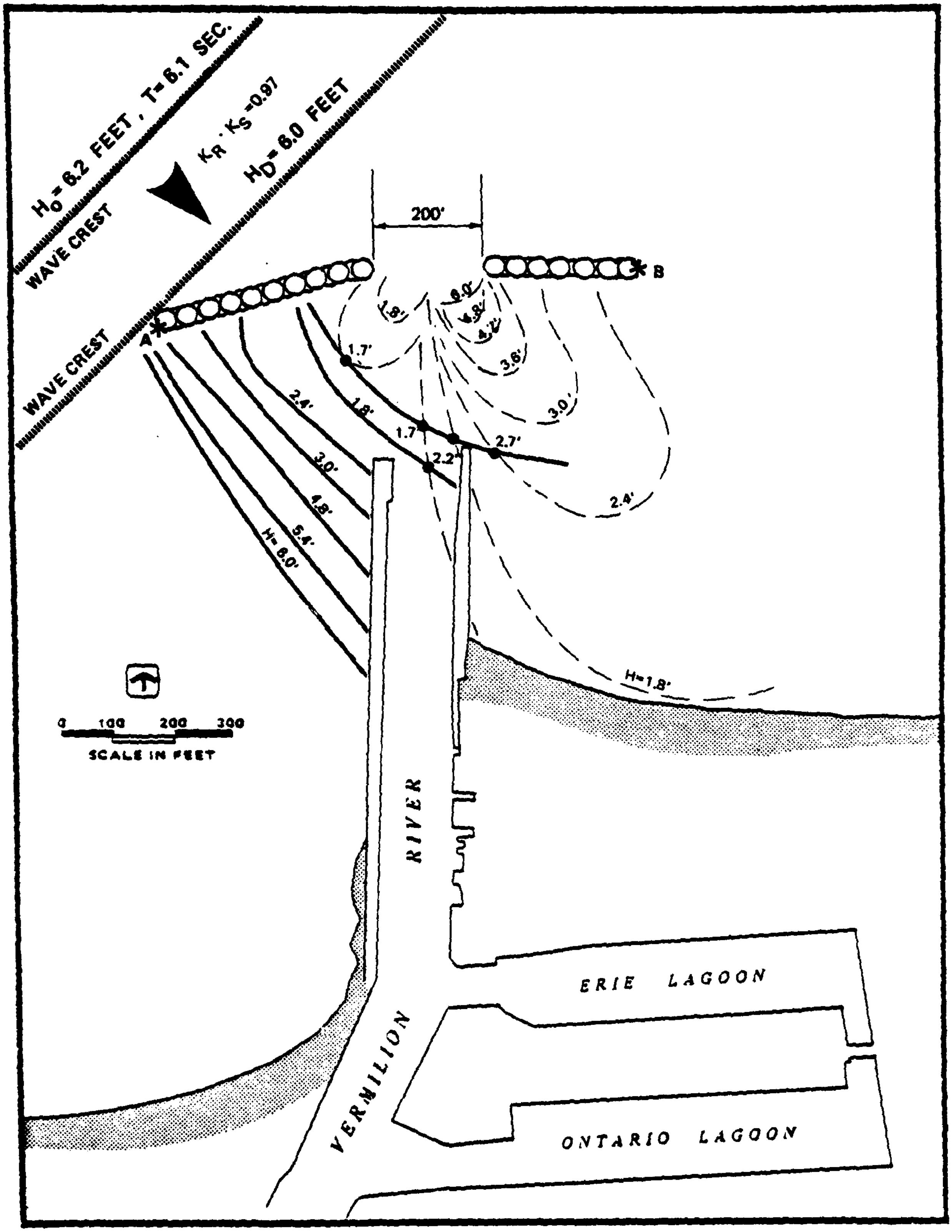



FIGURE 4.2.2J: DESIGN WAVE DIFFRACTION PATTERN, NORTHWEST WAVE APPROACH

a merging of diffraction effects caused by the breach and the west end (Point "A"). Where the lines of diffraction from these two conditions cross, conservation of wave energy requires that the average wave height, H, at each location is expressed by

$$H = \sqrt{\left(H_A\right)^2 + \left(H_G\right)^2}$$

where $H_A$ = wave height determined by diffraction at Point A.

$H_G$ = wave height determined by diffraction through the breakwater gap.

Because of wave superposition in the channel and wave reflection by the harbor piers, rough and choppy wave conditions would exist in the harbor entrance channel. However, navigation of small craft through the breakwater breach and into the river channel during the design wave condition would probably not be considered hazardous for the prudent boater. The area to the southeast of the breakwater gap would be the zone of the highest wave energy. Despite the rather turbulent nature of the wave activity within this zone, it appears that the design criteria for wave energy dissipation as set forth in the Corps of Engineers "General Design Manual" for Vermilion Harbor (1971), would be met at the river mouth.

CASE II: INCIDENT WAVES FROM THE NORTH

The design wave parameters for waves arriving from the north were as follows:

$H_o$ = deepwater significant wave height exhibiting a 20-year recurrence interval = 6.2 feet

$T_D$ = design wave period = 6.1 seconds

(Resio & Vincent, 1976)

Following the same procedures previously described, the effects of refraction and shoaling modify the incident deepwater wave height to a wave height, $H_D$, at the breakwater structure. The $K_r \cdot K_s$ factor in this case equals 1.12. For purposes of simplicity, only the wave diffraction at the gap was considered. Diffraction at the breakwater's east and west ends also plays a role in the wave height modification occurring outside the harbor piers, however, this role would clearly be secondary to the affect of the breakwater gap. Figure 4.2.2.2 shows the results of this wave analysis. This is clearly the "worst case" of the three wave approaches considered in this analysis. In the case of wave heights in the channel, the design wave would peak to a maximum height of 7.7 feet just inside the breakwater and proceed upriver sustaining a height of 4 feet or greater for a distance of 500 feet from the end of the east pier. The harbor entrance would be quite hazardous, possibly causing the loss of harbor use during periods of high waves. The condition of northern wave approach would cause the greatest concern for the safety of small boat traffic.

CASE III: INCIDENT WAVES FROM THE NORTHEAST

Similar to the first two cases discussed, the design wave arriving from the northeast was chosen from the wave statistics compiled by Resio and Vincent (1976). The design wave parameters are as follows:

$H_o$ = deepwater wave height, 20-year recurrence interval = 5.9 feet

$T_D$ = 6.2 seconds

The effect of wave refraction and shoaling is shown to decrease the height of the deepwater incident wave, $H_o$, to 0.97 $H_o$ (= 5.7 feet) at the breakwater structure. Using a method analogous to that of Case I, the diffraction effects at the gap and at the east side of the breakwater (Point "B") are considered. The results of this analysis are shown in Figure 4.2.2.3.

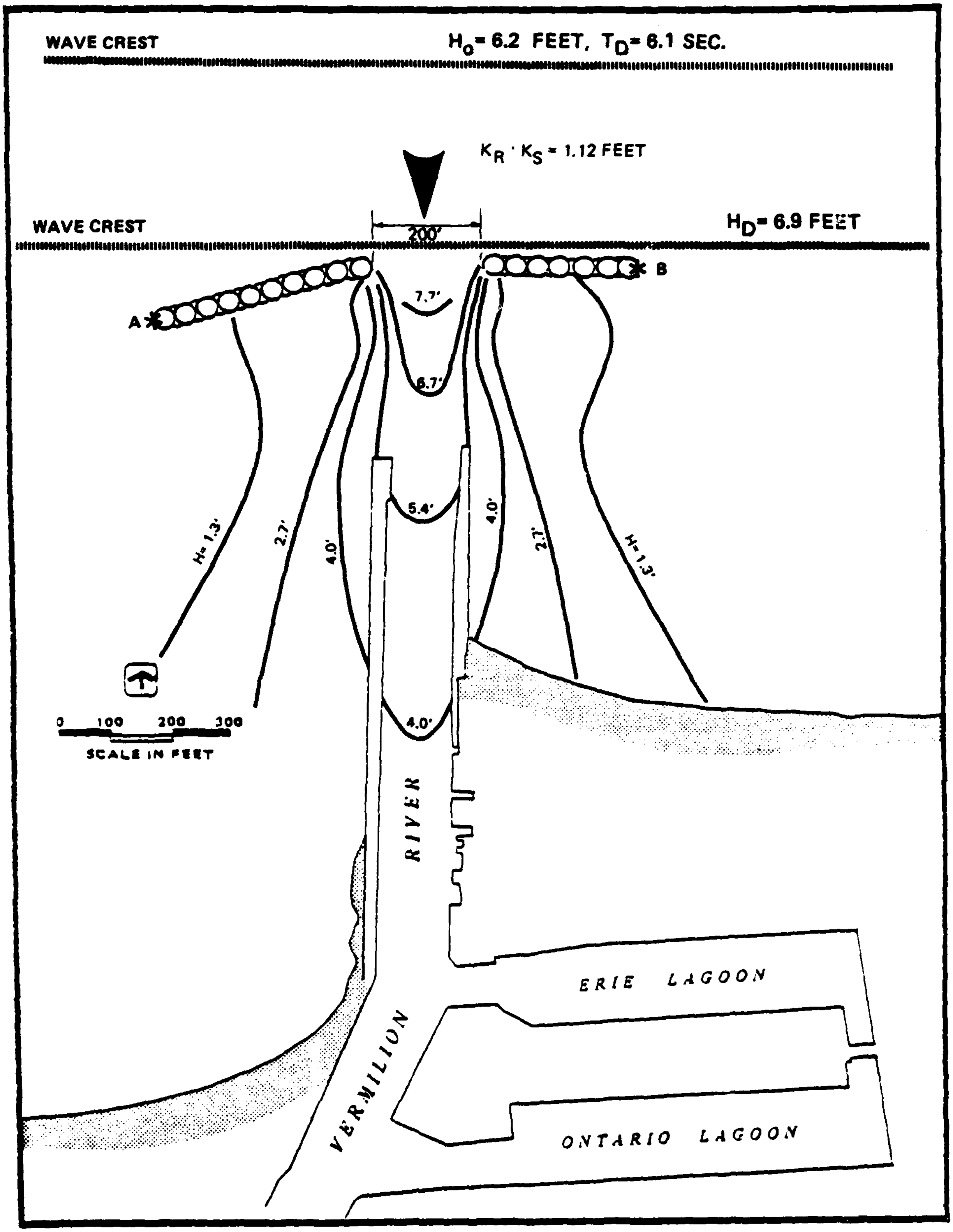



FIGURE 4.2.2.2: DESIGN WAVE DIFFRACTION PATTERN, NORTH WAVE APPROACH

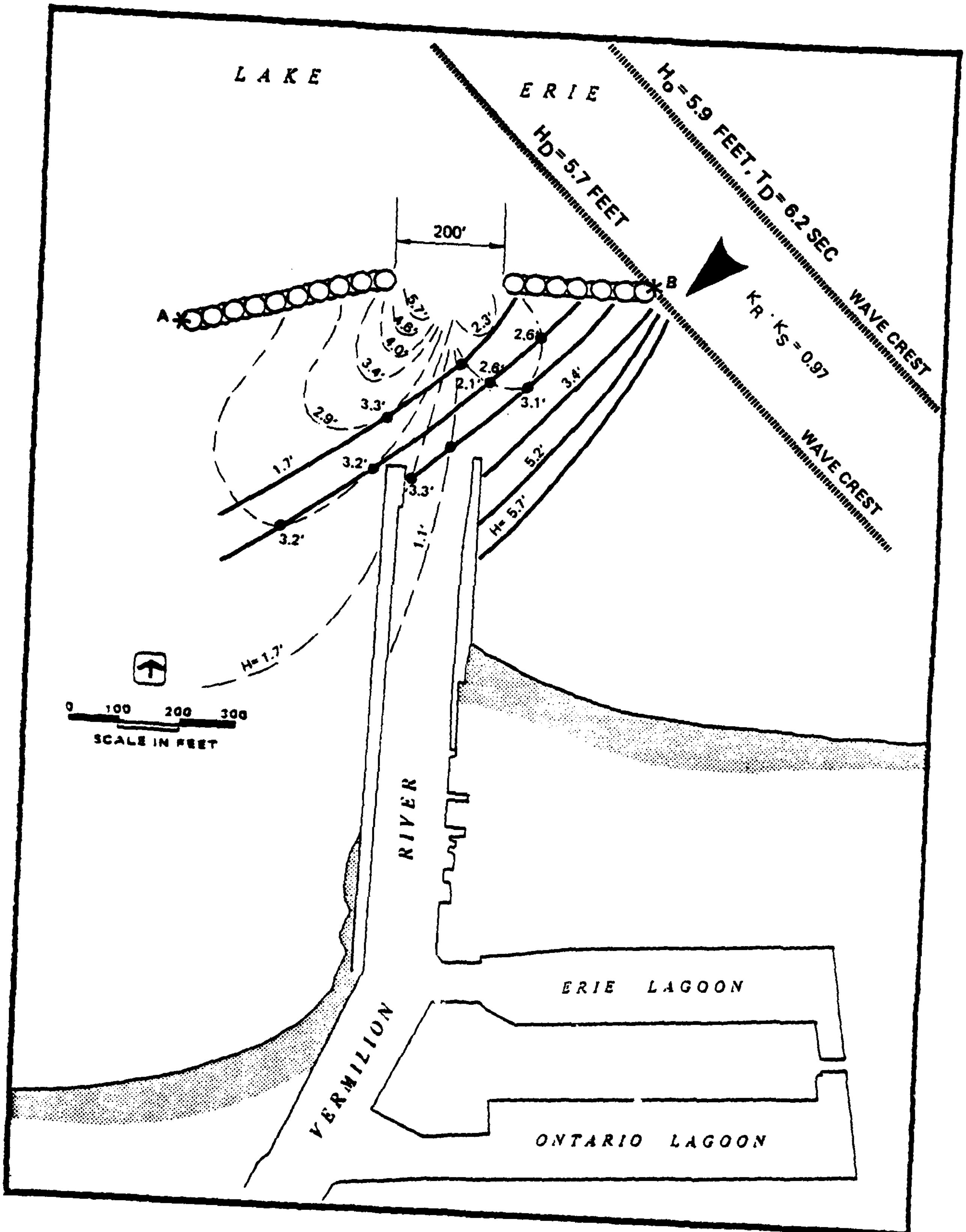



FIGURE 4.2.2.3: DESIGN WAVE DIFFRACTION PATTERN, NORTHEAST WAVE APPROACH

As in the previous cases described, the wave protection provided by the present breakwater is diminished when the central portion of the structure is removed. Wave heights in excess of 3 feet are expected in the entrance channel at the ends of the piers. This value is slightly above the Corps criteria of limiting wave heights to 2.5 feet at the harbor entrance bounded by the piers. Transiting the breakwater during periods of high northeast wave energy could be hazardous to small craft if care in navigation was not exhibited. The condition of northeast wave approach is clearly less hazardous than the case of waves arriving from due north.

4.2.3 Effect on Stability of Adjacent Shores

Breaching the Vermilion breakwater will allow wave energy to proceed through the gap into the harbor entrance that is currently well protected. This wave energy, if the breach was implemented, would serve to transport a portion of the sediment that is currently impounded in the breakwater's lee out to nearshore areas adjacent to the piers. Figure 4.2.3.1 shows generalized views of the expected sand movement under northwest and northeast wave conditions. In both cases, some material that is currently impounded in the breakwater's lee could be transported to the foreshore zones to the east and west. It can also be predicted that the areal extent of the zone of sand deposition behind the breakwater will decrease if the breakwater gap is created. In addition, some sediment would be transported to the south between the piers. During periods of northern wave approach, the movement of sand to the south within the channel would likely predominate over transport parallel to the lakeshore.

At the present time, sand transported in the littoral zone is impounded in the calm waters of the breakwater's lee. The required magnitude of mechanical transfer of material from this location to adjacent shores should diminish in the future if this design concept is implemented. Some additional dredging in the Vermilion River channel may be required due to the wave-induced transport of sediment up-river. During periods of high river discharge, sediment within the piers should be flushed directly out the gap to the lake. Because exposure to open lake conditions will affect the mechanical operations required to transfer this sediment to adjacent shores or to a disposal site, maintenance

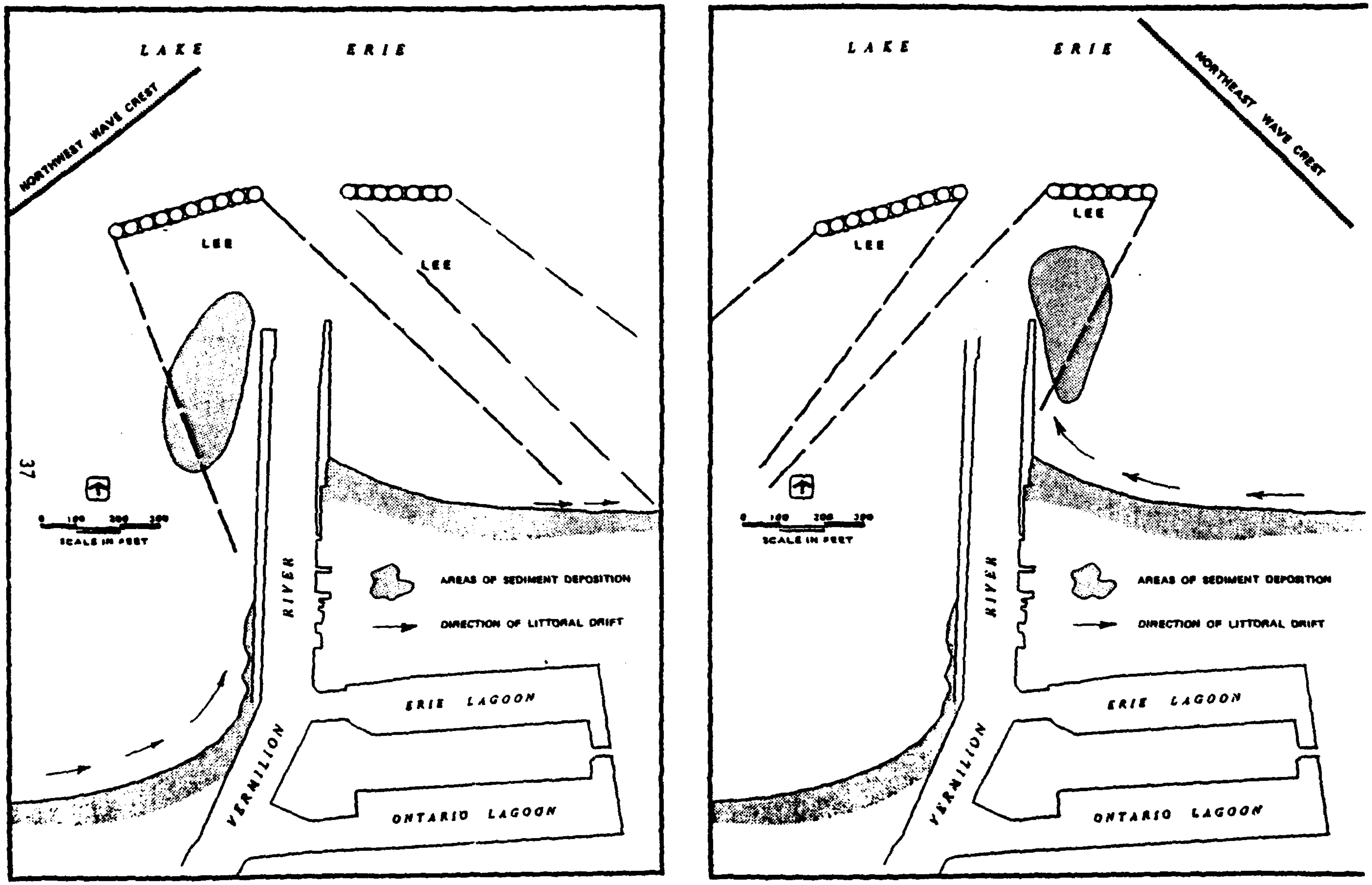



FIGURE 4.2.3.I: SAND TRANSPORT PATTERNS, ALTERNATIVE 2

dredging operations must be restricted to calm weather periods.

### 4.2.4 Cost

The cost of removing a central 200-foot long segment of the breakwater has been estimated using the information provided by Luedke Engineers of Frankfort, Michigan; the original construction contractor for the breakwater. The cost computations are presented in the Appendix. The general design of the sheet pile cells is shown in Figure 4.2.4.1. The cost estimate associated with breaching the breakwater and appropriate channel deepening is shown in Table 4.5. It is apparent based on subsurface investigations undertaken by the Corps of Engineers that some rock removal is required to create the proposed 15-foot channel.

TABLE 4.5: COSTS† OF BREAKWATER BREACH AND CHANNEL DREDGING

A. Sheet Pile Cell Demolition And Removal

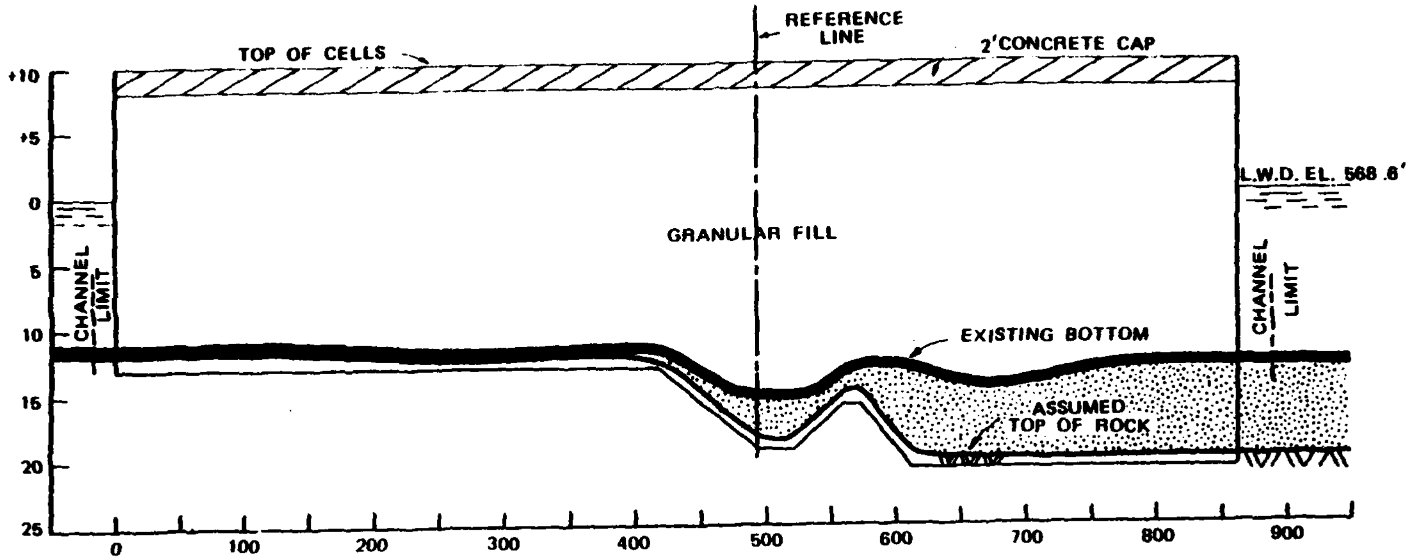
| | | | |
|---|---|---|---|
| Mobilization/Demobilization | | | $ 10,000 |
| Cell and Steel Membrane Removal | | | 367,500 |
| Subtotal | | | $377,500 |

B. Channel Deepening To -15 feet (LWD)*

| | Volume (c.y) | Unit Cost | |
|---|---|---|---|
| Sediment | 9200 | $ 7 | 64,400 |
| Rock | 2400 | $30 | 72,000 |
| Mobilization/Demobilization | | | 10,000 |
| Subtotal | | | 146,400 |
| Contingency (15%) | | | 22,000 |
| Subtotal | | | 168,400 |
| Subtotal ( A+B) | | | 545,200 |
| Engineering/Design (20%) | | | 109,200 |
| Supervision/Inspection (6%) | | | 32,800 |
| Overhead (5.6%) | | | 30,600 |
| | | TOTAL: | $718,500 |

† 1980 costs

* See Figure 4.2.1 for limits of 15-foot channel. Dredge volume is in addition to that required for the authorized 12-foot channel depth.



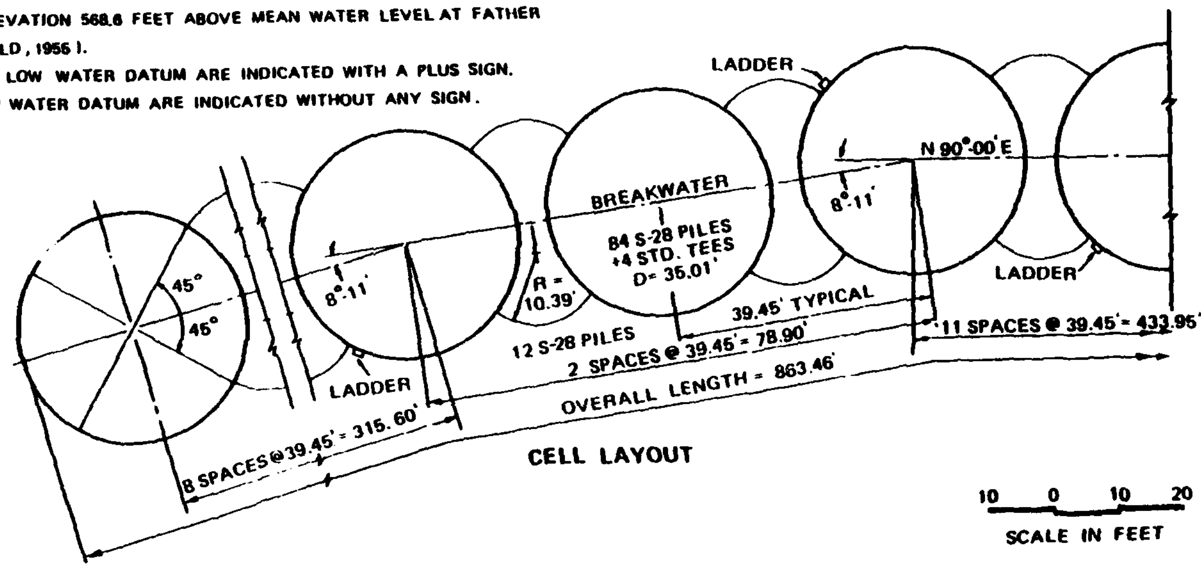

BREAKWATER PROFILE

GENERAL NOTES:

DEPTHS ARE IN FEET AND TENTHS AND REFERRED TO LOW WATER DATUM FOR LAKE ERIE, ELEVATION 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC ( IGLD, 1955 ).

ELEVATIONS ABOVE LOW WATER DATUM ARE INDICATED WITH A PLUS SIGN.

DEPTHS BELOW LOW WATER DATUM ARE INDICATED WITHOUT ANY SIGN.




CELL LAYOUT

FIGURE 4.2.4.1: OFFSHORE BREAKWATER DESIGN

### 4.2.5 Future Maintenance Costs

In Section 4.1.5, future maintenance costs associated with channel dredging adjacent to Vermilion Harbor were estimated based on past dredging operations and considerations of future incoming sediment loads. Because the option presently under consideration will provide wave energy to naturally remove sediment from the harbor entrance and river mouth to the nearshore zone adjacent to the harbor complex, the costs associated with entrance channel maintenance dredging should diminish relative to the current breakwater configuration. It is estimated that 4,550 cubic yards of material will require annual removal to maintain the proposed 15-foot channel. This is approximately 80% of the existing dredge requirement. The computations that support this analysis are presented in the Appendix. In the future, it is anticipated that the dredged volume required will decrease as updrift supplies of sand are depleted. Table 4.6 illustrates the expected annual dredge requirements if Alternative II is implemented.

TABLE 4.6: ANTICIPATED ANNUAL MAINTENANCE DREDGING COSTS*, ALTERNATIVE 2

| | |
|---|---|
| Volume (cubic yards) | 4,550 |
| Unit Cost | $ 7/c.y. |
| Subtotal | 31,900 |
| Mobilization/Demobilization | 10,000 |
| Subtotal | 41,900 |
| Contingency (15%): | 6,300 |
| Subtotal | 48,200 |
| Engineering/Design (20%): | 9,600 |
| Supervision/Inspection (6%): | 2,900 |
| Overhead (5.6%): | 2,700 |
| TOTAL | $63,400 |

* 1980 Costs

### 4.2.6 Summary

By creating a breach in the offshore breakwater at Vermilion and deepening the transit channel through this breach to -15 feet (LWD), the probability of ice jam formation at the river mouth would increase, approaching

that which existed prior to breakwater construction. A critical element that must be considered in this regard is the absolute necessity of ice breaking at the breach if severe ice jam conditions exist (i.e. a harsh winter followed by a rapid thaw). Should ice breaking operations not be performed through the breach, the ice contained in the windrows could block a portion of the river mouth and cause a constriction of flow that would increase the potential for ice jam flooding over that which presently exists with the breakwater intact.

The major disadvantage of this alternative is the detrimental effect that such a plan would have on the navigational safety within the harbor entrance and river channel during periods of northern wave approach. Currently, the Vermilion breakwater provides the harbor with excellent wave protection. Wave analyses show that the creation of a gap in the breakwater would, during periods of high waves from the north, cause hazardous wave conditions within the harbor entrance.

In terms of adjacent beach changes, the exposure of sediment to wave energy passing through the breakwater gap allows sediment transport both into the breakwater's lee and out of this zone depending on the direction and magnitude of the incoming waves. This results in a decrease in the future dredging requirements of the Vermilion Harbor entrance as well as the redistribution of temporarily impounded sediment to adjacent beaches.

## 4.3 ALTERNATIVE 3: REMOVAL OF BREAKWATER

Removal of the breakwater must be accompanied by dredging activities that will deepen the entrance channel to the 15-foot depth required for the 140-foot ice breaker.

### 4.3.1 Effect on Ice Formation

If the offshore breakwater is removed, the winter ice conditions adjacent to Vermilion Harbor would return to those that existed prior to the construction of the offshore breakwater. As shown in Figure 4.3.1.1, the windrow ice zone forms at the harbor mouth at the northern ends of the piers.

The ice upriver from this zone is smooth and overlies the river flow. If the windrow formation at the river mouth is severe, blockage of the river flow would occur causing the water levels in back of this obstruction to rise until either the jam was broken, or the rising backwater overflowed the jam or other containment boundaries.

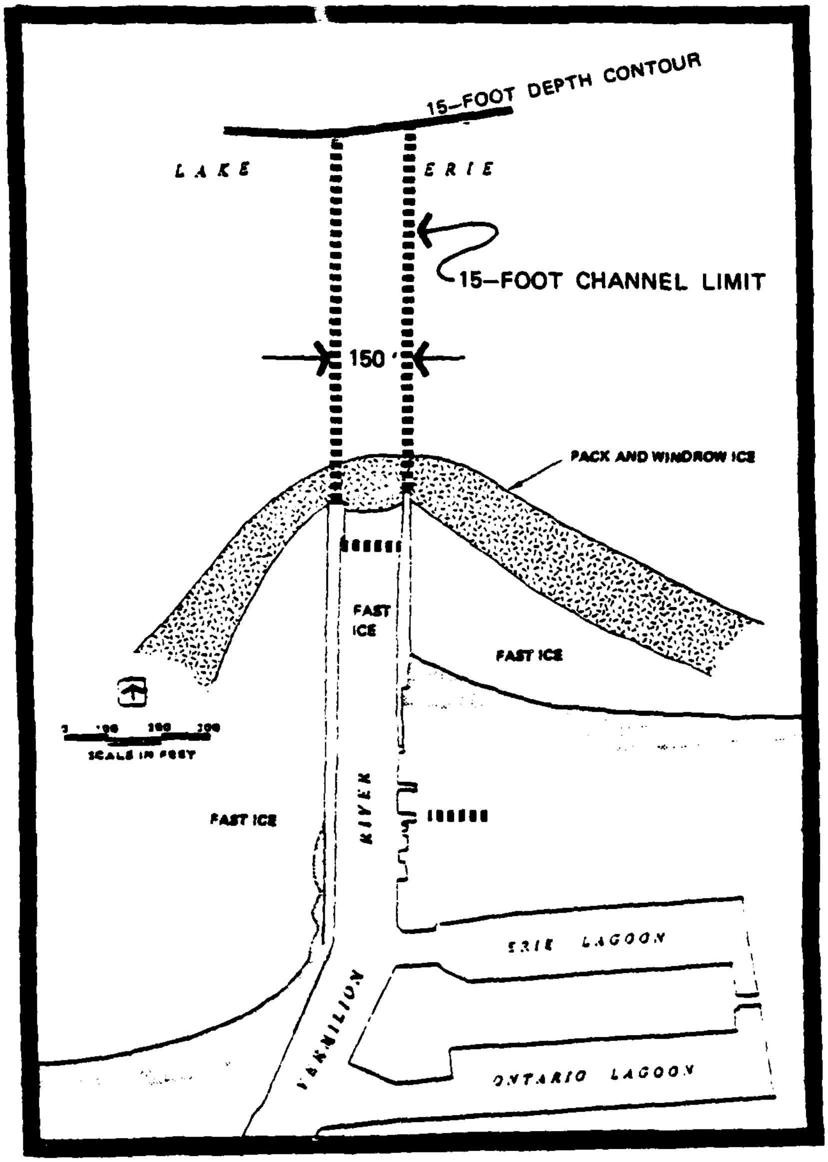



FIGURE 4.3.1.1: ICE FORMATION WITHOUT BREAKWATER, VERMILION HARBOR

Deepening the 150-foot wide entrance channel to the fifteen-feet required by the 140-foot ice breaker will create additional channel volume through which the river discharge can escape to the lake beneath the ice field. This will cause an improved situation in terms of ice jam flooding potential relative to the prebreakwater condition when a twelve-foot channel depth existed.

Prior to 1973, the Coast Guard's 110-foot vessel was deployed routinely to participate in ice clearance operations at Vermilion. If the breakwater is now removed, it is believed that the new 140-foot ice breaker would also have to provide ice breaking services on a routine basis.

### 4.3.2 Effect on Wave Climate/Navigation

The vessels that use Vermilion Harbor are shallow draft and are exclusively devoted to recreation and commercial fishing pursuits. Prior to the construction of the offshore breakwater, vessel operations were unsafe and limited at the harbor entrance during periods of moderate to high storm waves (U.S. Army, Corps of Engineers, 1970). At such times, vessels encountering following or quartering seas had to maintain sufficient speed to maintain steerageway. If a boat was underpowered, this situation could prove quite hazardous. Sailing vessels also experienced difficulty in transiting the entrance channel under these conditions. The wave climate in Vermilion Harbor without the breakwater can be predicted simply by referring to the pre-1973 condition. To include this condition herein, the results of the Vermilion Harbor model study conducted by the U.S. Army Corps of Engineers Waterways Experiment Station (Brasfeild, 1970) were used. The choice of the design waves that have been applied to the model study results for the southwest, north, and northeast directions were determined (as previously discussed in Section 4.2.2 of this report) using the information presented by Resio and Vincent (1976).

The Vermilion Harbor modeling study described the "base test" condition (i.e. the wave heights at various locations prior to the construction of the breakwater). The results of this "base test" serve as the basis for the determination of the effect that breakwater removal will have on harbor wave conditions.

The report of the scale model study documents the wave conditions at various locations adjacent ot the harbor for a variety of input wave heights and periods. The "base test" model study wave parameters that most closely approximate the design wave values chosen from the Resio and Vincent report are for a six foot deepwater wave height, with a seven second period. The difference between the prototype wave period studied in the model (7 seconds), and the design wave periods chosen here ( ~ 6 seconds) is assumed to be negligible for the purposes of this analysis.

The prototype wave height of six feet studied in the model is slightly different than the design wave heights chosen for this analysis. By applying a correction factor, f,

$$f = \frac{\text{design wave height}}{\text{prototype wave height in model}},$$

the results of the model study can be roughly transformed to describe the expected wave conditions at the various wave measurement locations in the model for the design wave condition.

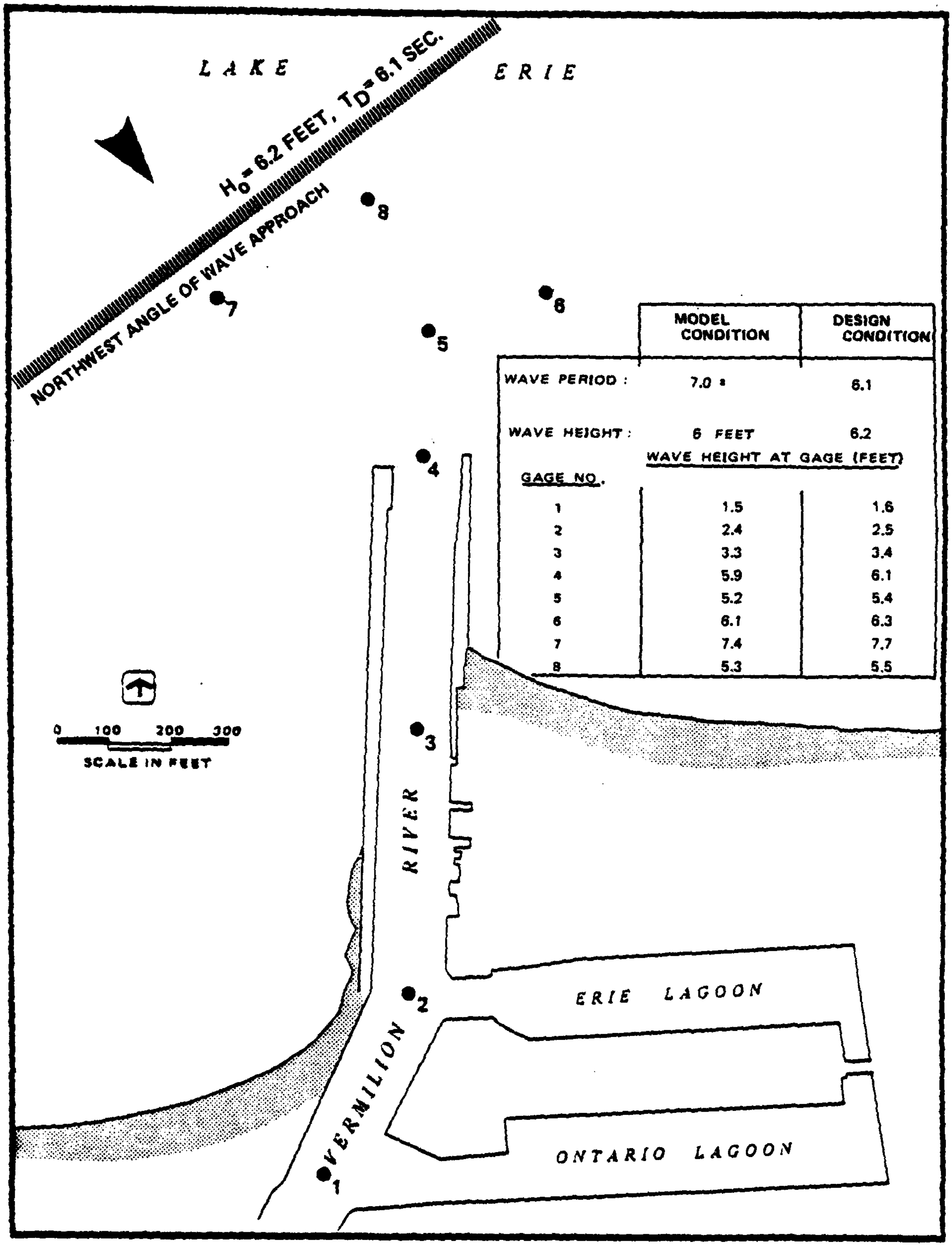
CASE I: *INCIDENT WAVES FROM THE NORTHWEST*

For this condition, the design wave parameters exhibiting a 20-year recurrence interval are as follows:

$H_0$ = deepwater significant wave height = 6.2 feet

$T_D$ = design wave period = 6.1 seconds (Resio and Vincent, 1976)

The Vermilion Harbor wave study report documents the results of the "base test" for the case of northeast wave approach only. For the purposes of this study, we will assume that symmetry dictates the equivalence of the northeast and northwest base test conditions. Figure 4.3.2.1 presents the expected wave height at each of the wave gage locations for the design wave condition.




| | MODEL CONDITION | DESIGN CONDITION |
|---|---|---|
| WAVE PERIOD : | 7.0 s | 6.1 |
| WAVE HEIGHT : | 6 FEET | 6.2 |
| | WAVE HEIGHT AT GAGE (FEET) | |
| GAGE NO. | | |
| 1 | 1.5 | 1.6 |
| 2 | 2.4 | 2.5 |
| 3 | 3.3 | 3.4 |
| 4 | 5.9 | 6.1 |
| 5 | 5.2 | 5.4 |
| 6 | 6.1 | 6.3 |
| 7 | 7.4 | 7.7 |
| 8 | 5.3 | 5.5 |

FIGURE 4.3.2.1: DESIGN WAVE ANALYSIS, NORTHWEST WAVE APPROACH

The actual wave heights given at each gage location by the model have been increased by a factor of 1.03 = 6.2/6.0, the ratio of design incident wave height to the model incident wave height. This analysis shows that under the design case, a wave of 6.1 feet would exist at the harbor mouth. Because of diffraction effects, this value of wave height would decrease quickly once inside the piers to 3.4 feet at Station #4, 2.5 feet at Station #2, and 1.6 feet at Ontario Lagoon.

CASE II: <u>INCIDENT WAVES FROM THE NORTH</u>

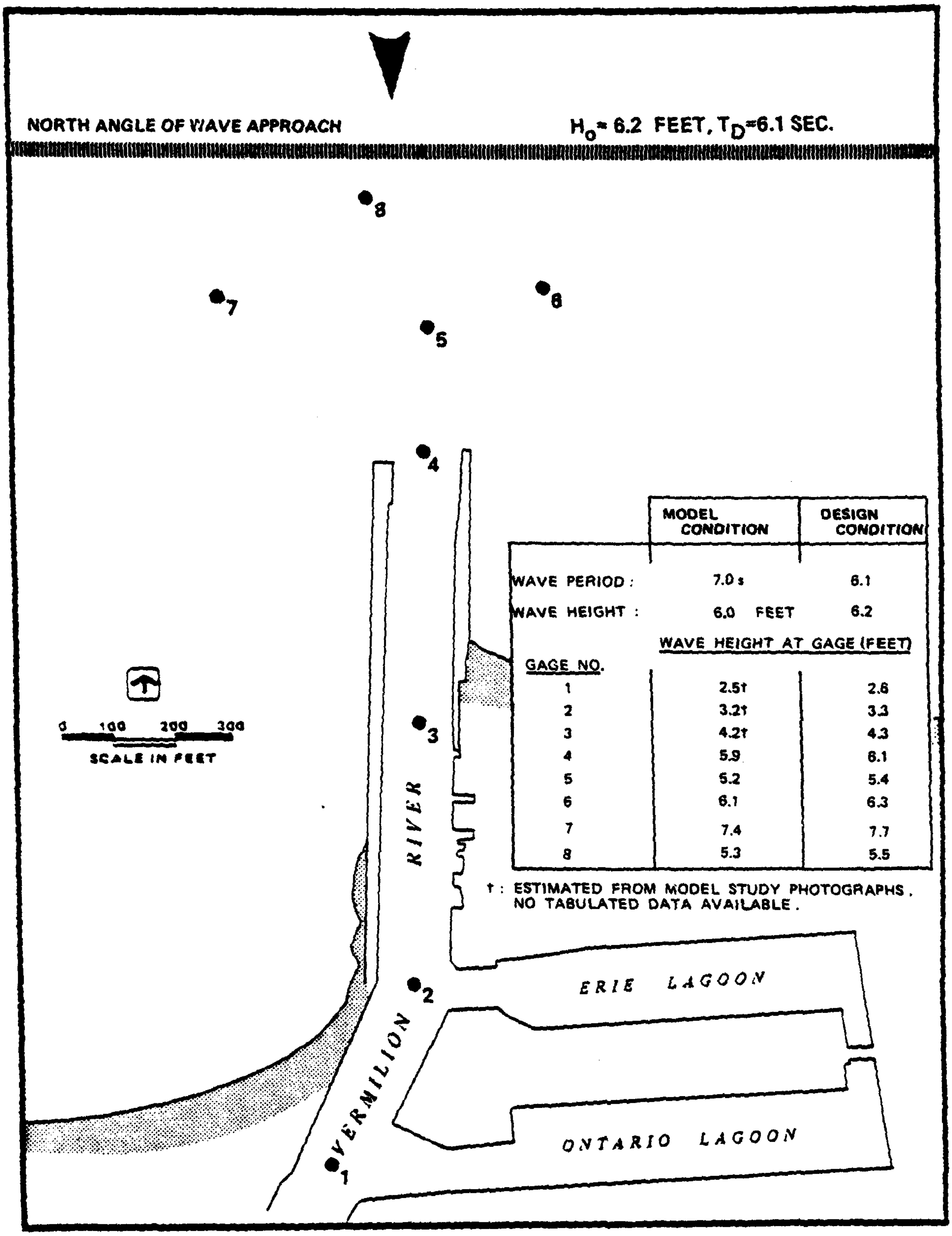
The model study results were also utilized to predict the heights of waves at the various gauge locations during periods of northern wave incidence. Information from Resio and Vincent (1976) yields the following design wave parameters:

$H_o$ = design significant wave height, 20-year RI = 6.2 feet

$T_D$ = design wave period = 6.1 seconds

The Vermilion model study did not report results for northern wave conditions. Model photographs of tests employing northern wave approach were available, however, from which visual estimates of wave heights were made for locations between the piers and at the upriver wave gage locations. For the offshore gage locations, the model data that describes wave heights for northeast wave approach were considered adequate to develop a quantitative understanding of similar wave conditions during periods of northern wave approach. Because northern waves would pass directly into the jettied entrance without diffraction-induced energy dissipation, wave heights in the channel would be significantly higher at Stations 1, 2 and 3 than shown under conditions of northeast waves. Figure 4.3.2.2 illustrates the expected wave heights at the locations of wave gauges in the model study.

The upstream stations denote estimated wave heights based on examination of model study photographs. No tabulation of model study heights are available for this wave condition. The actual wave heights given at each




| | MODEL CONDITION | DESIGN CONDITION |
|---|---|---|
| WAVE PERIOD : | 7.0 s | 6.1 |
| WAVE HEIGHT : | 6.0 FEET | 6.2 |
| | WAVE HEIGHT AT GAGE (FEET) | |
| GAGE NO. | | |
| 1 | 2.5† | 2.6 |
| 2 | 3.2† | 3.3 |
| 3 | 4.2† | 4.3 |
| 4 | 5.9 | 6.1 |
| 5 | 5.2 | 5.4 |
| 6 | 6.1 | 6.3 |
| 7 | 7.4 | 7.7 |
| 8 | 5.3 | 5.5 |

† : ESTIMATED FROM MODEL STUDY PHOTOGRAPHS. NO TABULATED DATA AVAILABLE.

FIGURE 4.3.2.2: DESIGN WAVE ANALYSIS, NORTH WAVE APPROACH

location by the model results have been increased by a factor of 1.03 (= 6.2/6.0), the ratio of the design wave height to the model incident wave height. The data shows that the wave height between the piers and at the upriver locations will be about one foot higher for the case of northern wave approach relative to the northeast wave approach.

CASE III: INCIDENT WAVES FROM THE NORTHEAST

This condition was modelled in the study of Vermilion Harbor by the U.S. Army, Corps of Engineers, Waterways Experiment Station (Brasfeild, 1970). The design wave parameters for this direction are as follows:

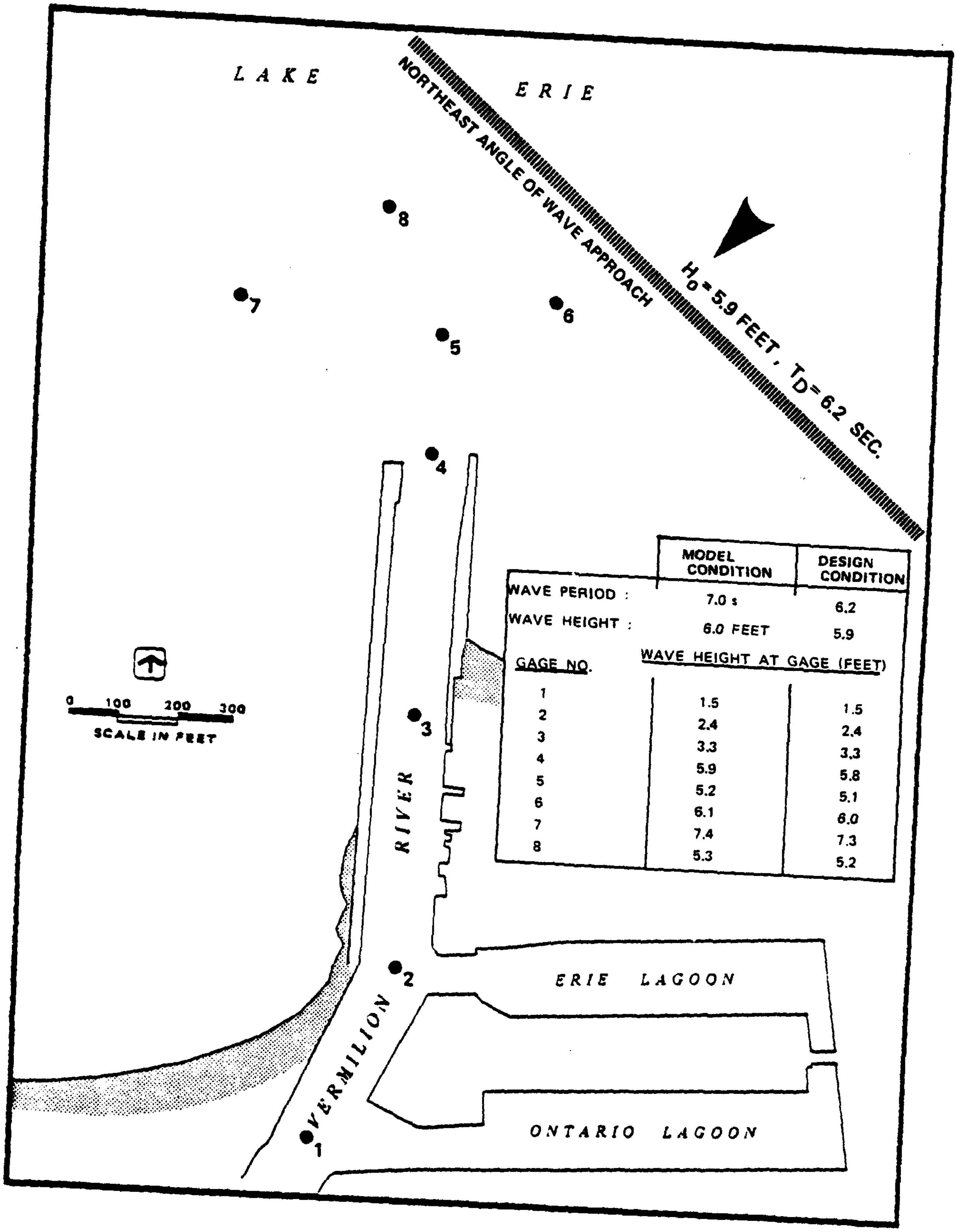
$H_O$ = design significant wave, 20-year RI = 5.9 feet

$T_D$ = design wave period = 6.2 seconds

Because the incident wave generated in the hydraulic model was 6 feet, the results of that study were transformed to this design wave condition using a ratio equal to 0.98 (= 5.9/6.0). Figure 4.3.2.3 illustrates the expected wave conditions associated with this design option. Under these incident wave conditions, the wave height at the river mouth would be about 6 feet. In the river channel, Station 3 would experience wave heights of 3.3 feet and Station 2 would have 2.4 foot wave heights. Model study photos show that wave reflection off the pier faces would cause the river channel to be choppy under these circumstances.

Wave Study Summary

The removal of the Vermilion breakwater will cause an increase in the wave heights at the harbor entrance and in the adjacent river channel. The severity of these conditions has been estimated using the results of the model study conducted by the Corps of Engineers in 1970. It appears that the design wave conditions between the parallel piers under the circumstance of breakwater removal would cause a choppy, turbulant sea of 3-4 foot wave heights.




| | MODEL CONDITION | DESIGN CONDITION |
|---|---|---|
| WAVE PERIOD : | 7.0 s | 6.2 |
| WAVE HEIGHT : | 6.0 FEET | 5.9 |
| GAGE NO. | WAVE HEIGHT AT GAGE (FEET) | |
| 1 | 1.5 | 1.5 |
| 2 | 2.4 | 2.4 |
| 3 | 3.3 | 3.3 |
| 4 | 5.9 | 5.8 |
| 5 | 5.2 | 5.1 |
| 6 | 6.1 | 6.0 |
| 7 | 7.4 | 7.3 |
| 8 | 5.3 | 5.2 |

**FIGURE 4.3.2.3: DESIGN WAVE ANALYSIS, NORTHEAST WAVE APPROACH**

The actual impact that breakwater removal would have on navigational safety should be very easy to ascertain simply by referring to the arguments and documented evidence that led to the breakwater's construction in 1973. The level of damage or disruption of local boating interests following breakwater removal would be more or less equivalent to that experienced during the pre-1973 period.

### 4.3.3 Effect on Stability of Adjacent Shores

The offshore breakwater at Vermilion is currently providing a zone of protected, calm water within which sand-sized sediment motion ceases. This area of sediment impoundment represents a loss of sand from adjacent beaches if the impounded sand is subsequently dredged and transported offshore for disposal. Removal of the breakwater would cause a gradual eastward migration of beach sediments adjacent to the east pier during periods of northwest wave activity. In addition, breakwater removal would precipitate some measure of sediment bypassing of the harbor from east to west during periods of northeast storms. However, the level of bypassing will be inhibited by the proposed 15-foot channel that will impound sediment passing into it. The release of a portion of the presently impounded material, while considered beneficial to adjacent shores, will not cause renewed, long-lasting stability on Vermilion beaches. Sediment sources along this section of lakeshore have been decreasing with time as shoreline fortification has proceeded in the past. This trend will continue in the future causing beach instability as the nearshore sand supply is depleted through entrapment and offshore loss.

### 4.3.4 Cost

The cost of breakwater removal has been estimated using the information supplied by the construction firm that built the structure (Luedke Engineers, Frankfort, Michigan). The computation of cost for removal is presented in the Appendix. The general design of the breakwater is presented in Section 4.2.4. Channel deepening to -15 feet (LWD) is included in these costs and future maintenance of the north-south entrance channel at -15 feet (LWD) is required.

TABLE 4.7: BREAKWATER REMOVAL COSTS

| | | |
|---|---|---|
| A. | Sheet Pile Cell Demolition and Removal | |
| | Mobilization/Demobilization | $ 10,000 |
| | Cell and Steel Membrane Removal | 1,292,600 |
| | Subtotal | $ 1,302,600 |
| B. | Channel Deepening to -15 Feet (LWD)* (As computed in Table 4.5) | 168,400 |
| | Subtotal (A + B) | 1,471,000 |
| | Engineering/Design (20%): | 294,200 |
| | Supervision/Inspection (6%): | 88,300 |
| | Overhead (5.6%): | 82,400 |
| | TOTAL | $1,935,900 |

† 1980 costs

* See Figure 4.3.1.1 for limits of 15-foot channel. Dredge volume is in addition to that required for the authorized 12-foot channel depth.

### 4.3.5 Future Maintenance Costs

If the breakwater was removed, the configuration of the entrance currently maintained by the Corps of Engineers would change. It is proposed that a north-south approach channel would be implemented having a depth of -15 feet (LWD). It is estimated that the maintenance associated with a 150-foot wide channel of these proportions will be unchanged from that currently maintained by the Corps. This is due to the impoundment basin that will characterize the proposed channel's performance. The expected annual volume of required dredging for Alternative 3 is estimated to be 7,450 cubic yards. This is equivalent to that required of Alternative 1 and represents 60% of the total volume of the proposed channel. Computations which support these estimates are presented in the Appendix. The expected annual maintenance dredge cost for Alternative 3 is $86,600 (as developed in Table 4.3).

4.3.6 Summary

There are no quantitative data available or evidence to indicate that removal of the Vermilion Harbor breakwater will reduce the probability of ice jam flooding. However, ice researchers for the U.S. Army Cold Regions Research and Engineering Laboratory have expressed the opinion that the breakwater does perform a valuable function as an ice barrier by keeping the ice windrow zone lakeward of the river channel. (see Reference 1, Section 8.2). Without the breakwater, ice breaking at the river mouth would be required to prevent ice jam formation between the piers.

The effect that breakwater removal would have on navigational safety during ice-free periods would be detrimental. The breakwater was constructed in 1973 to protect boaters from a very hazardous passage at the harbor entrance during times of moderate to high waves. The breakwater has served its function as a protective structure very well. Removal of the breakwater would return the harbor approach to its previous unprotected condition. Further, breakwater removal would lessen the intensification benefits* for small boat navigation which were a substantial portion of the total benefits upon which the 1973 modification was made.

Entrance channel maintenance costs of this alternative would be comparable to that of the present condition due to the ability of the proposed 15-foot channel to perform as a sediment impoundment basin. A realignment of the present east and west channels would be proper to allow for direct access to the lake through a 150-foot wide north-south transit channel.

* "Intensification benefits" are the benefits associated with the rate of return that increased usage has on vessel ownership.

## 4.4 COMPARISON OF ALTERNATIVES FOR DESIGN CONDITION #1 (140-Foot Coast Guard Vessel)

Three structural alternatives have been presented that seek to decrease the flooding potential due to ice jam formation at Vermilion Harbor. In addition, the "no action" alternative is also considered. In judging the relative merits of each proposal, the criteria specified in Section 3.0 must be reiterated. Each potential solution must be judged relative to the following elements:

1. Success in Relieving Ice Jam Flooding
2. Navigational Safety
   - o Coast Guard ice breaking vessel
   - o Small craft during ice-free periods
   - o Sedimentation
3. Engineering Feasibility
4. Beach Stability on Adjacent Shores
5. Cost
   - o Construction cost
   - o Maintenance cost
6. Environmental Impact
   - o Water quality
   - o Aesthetics
7. Acceptability
   - o Local
   - o Agency

The three ice jam mitigation alternatives presented previously together with the "no action" alternative must be compared and ranked in order to identify the most attractive scheme for further consideration and possible implementation. Evaluation will be done using a weighted value matrix considering the key criteria elements set forth above.

The evaluation matrix presented in Table 4.8 shows the results of the evaluation process. Note that the two channel deepening routes are considered in Alternative 1.

I = Importance Factor (0-10)
R = Rating Factor (0-3)
IR = Weighted Rating (I·R)

| ALTERNATIVE | DESCRIPTION | | FUNCTIONAL/ENGINEERING: ICE JAM MITIGATION SUCCESS | FUNCTIONAL/ENGINEERING: NAV. SAFETY: COAST GUARD ICEBREAKER | FUNCTIONAL/ENGINEERING: NAV. SAFETY: ICE-FREE PERIODS | FUNCTIONAL/ENGINEERING: SEDIMENTATION | FUNCTIONAL/ENGINEERING: CONSTRUCTION FEASIBILITY | FUNCTIONAL/ENGINEERING: SUBTOTAL | ENVIRONMENTAL: BEACH STABILITY | ENVIRONMENTAL: WATER QUALITY | ENVIRONMENTAL: AESTHETICS | ENVIRONMENTAL: SUBTOTAL | ECONOMIC: CONSTRUCTION COST | ECONOMIC: MAINTENANCE COST | ECONOMIC: SUBTOTAL | ACCEPTABILITY: LOCAL | ACCEPTABILITY: AGENCY | ACCEPTABILITY: SUBTOTAL | SCORE | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | 8 | 7 | 8 | 6 | 8 | | 7 | 7 | 5 | | 7 | 7 | | 9 | 7 | | | |
| 1 | Deepen Channel *Route I | R | 2 | 2 | 3 | 1 | 1 | | 1 | 2 | 1 | | 1 | 1 | | 2 | 1 | | 133 | 3 |
| | | IR | 16 | 14 | 24 | 6 | 8 | 89 | 7 | 14 | 5 | 26 | 7 | 7 | 14 | 18 | 7 | 25 | | |
| | *Route II | R | 2 | 2 | 3 | 1 | 2 | | 1 | 2 | 1 | | 2 | 2 | | 2 | 3 | | 169 | 1 |
| | | IR | 16 | 14 | 24 | 6 | 16 | 97 | 7 | 14 | 5 | 26 | 14 | 14 | 28 | 18 | 21 | 39 | | |
| 2 | Breach Breakwater and Deepen | R | 2 | 2 | 1 | 2 | 1 | | 2 | 3 | 1 | | 1 | 2 | | 1 | 1 | | 145 | 4 |
| | | IR | 16 | 14 | 8 | 12 | 8 | 75 | 14 | 21 | 5 | 40 | 7 | 14 | 21 | 9 | 7 | 16 | | |
| 3 | Remove Breakwater (only) | R | 1 | 0 | 1 | 2 | 2 | | 2 | 3 | 2 | | 0 | 2 | | 2 | 1 | | 128 | 5 |
| | | IR | 8 | 0 | 8 | 12 | 16 | 44 | 14 | 21 | 10 | 45 | 0 | 14 | 14 | 18 | 7 | 25 | | |
| 4 | No Action | R | 1 | 0 | 3 | 1 | 3 | | 1 | 2 | 1 | | 3 | 2 | | 2 | 3 | | 162 | 2 |
| | | IR | 8 | 0 | 24 | 6 | 24 | 83 | 7 | 14 | 5 | 26 | 21 | 14 | 35 | 18 | 21 | 39 | | |

TABLE 4.8 : EVALUATION MATRIX

Based on information gathered from City officials, the U.S. Coast Guard, the U.S. Army Corps of Engineers, the Vermilion Port Authority and area residents, each evaluation element considered was assigned an importance factor, "I" (0 = no importance through 10 = very important). Assignment of values for these factors undoubtedly are subjective and highly dependent on sensitivity to area interests but, applied on an equal basis to all schemes, this approach provides a relative means for ranking. The rating factor, "R" ( 0 through 3), is used for rating each scheme relative to the evaluation elements, subsequently to be multiplied by the importance factor, "I", to arrive at a weighted rating, "IR", representing the scheme's score for that particular evaluation element. The sum of all the weighted ratings for each mitigation scheme is the basis for their subsequent ranking.

Based on this evaluation procedure, the most attractive alternative to decrease the flooding potential due to ice jam formation is the dredging of a fifteen foot channel at the east harbor entrance. In this way, the new 140-foot Coast Guard vessel can effectively break through the windrow ice zone and create a path through which broken ice can escape from the river to the lake.

## 5.0 EVALUATION OF ALTERNATIVES FOR DESIGN CONDITION NO. 2: 110-FOOT COAST GUARD VESSEL

The Coast Guard has indicated that the traditionally used 110-foot ice breaking vessel will no longer be available to serve the future needs of the City of Vermilion. This vessel, which has shown its effectiveness and ability to conduct safe and efficient ice breaking operations in the authorized 12-foot depths of Vermilion Harbor, will soon be replaced by a 140-foot vessel that requires 15 feet of water depth for safe navigation.

For Design Condition No. 2 that employs the 110-foot vessel, no channel or harbor modification is required to allow ice breaking activities to be successfully undertaken. The Coast Guard has shown the ability to enter the harbor to perform ice breaking operations on numerous occasions since the offshore breakwater was installed in 1973. The winter of 1980 showed the ability of the 110-foot ARUNDEL to safely navigate through the harbor entrance.

This serves to indicate that if the 110-foot vessel was still available for ice breaking in Vermilion Harbor, no channel or structural modification of the federal navigation works at Vermilion would be required. This is borne out by the 1980 Report of Ice Breaking Assistance, prepared by the Corps of Engineers Cleveland Project Office, which states:

> "Ice breaking on 20 February 1980 was extremely effective in allowing the mouth and upstream to the Route 6 bridge to be clear. If the Vermilion (city) ice breaker had not broken down on 22 February, the entire river could have been cleared and there may not have been any ice jams at all".

As stated previously, it is the opinion of the U.S. Army Cold Regions Research and Engineering Laboratory that the offshore breakwater at Vermilion serves a useful purpose in reducing the threat of ice jam formation at the mouth of the Vermilion River. Furthermore, historical ice jam formation

during the pre- and post-breakwater period have shown that no upstream flooding has occurred due solely to the stagnation of ice floes at the breakwater. Flooding that has occurred traditionally at upstream locations is due to ice jam formation at river bends and at locations of major structural projections into the river (bridge piers, projecting bulkheads). To reiterate, no channel or harbor modification is deemed necessary for Design Condition No. 2 in which the 110-foot Coast Guard vessel is available for ice breaking service.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### Design Condition No. 1: 140-Foot Coast Guard Vessel

The evaluation procedure undertaken and presented in Section 4.4 of this report is the basis for the recommendations presented. The Route II channel deepening scheme of Alternative I rated the best of all the mitigation schemes considered for the 140-foot vessel. In addition, this plan was also judged to be better than the "No Action" alternative. The proposed channel configuration for this plan (shown again in Figure 6.1) allows for the passage of the new 140-foot class Coast Guard icebreaker on the east side of the Vermilion Harbor entrance.

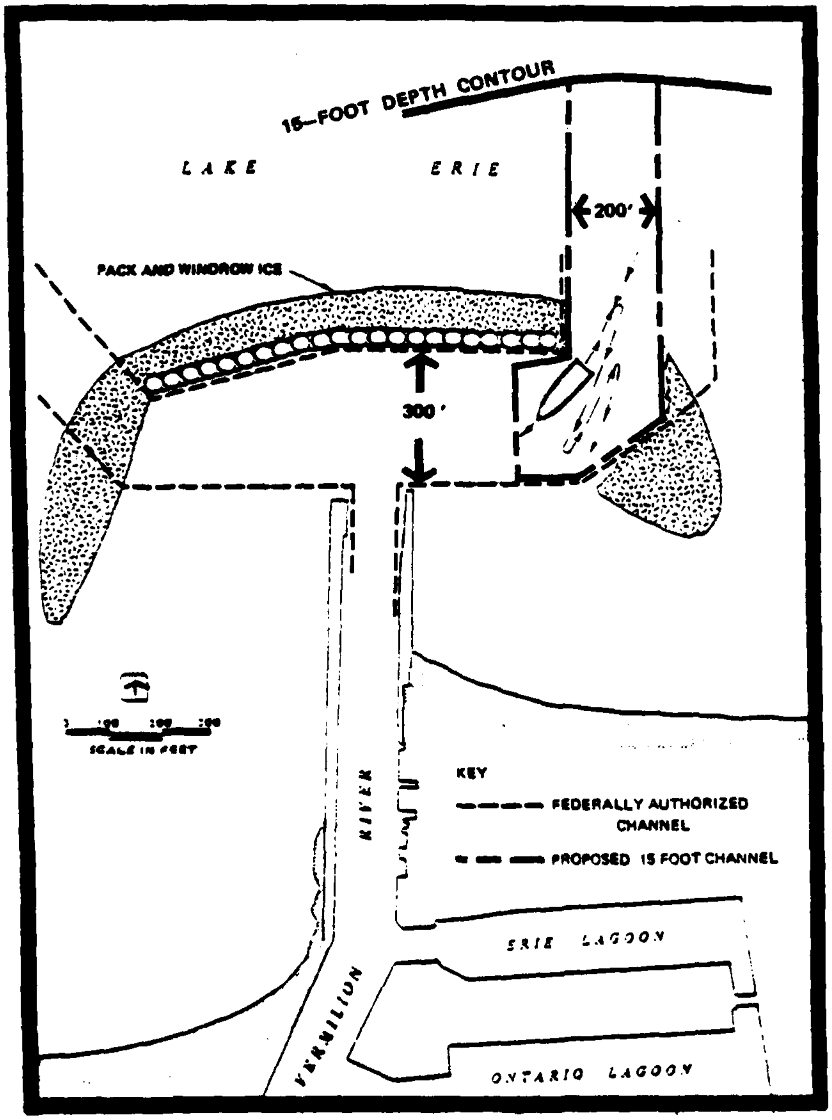



FIGURE 6.1: RECOMMENDED MITIGATION SCHEME, ALTERNATIVE 1, ROUTE II

For this reason, the expensive blasting and rock dredging operations specified for Route I can be avoided. The opinions of the Coast Guard led to the belief that opening only the east entrance channel was a feasible and acceptable condition for vessel operation. It must be stressed, however, that the full range of operational characteristics of the new 140-foot ice-breakers are not clearly defined at present. The ice breaking procedures posed to the Coast Guard seemed reasonable but the proof of acceptability must await the initial attempt to perform these maneuvers. The construction cost of the proposed 15-foot channel is $186,700. The anticipated annual channel maintenance cost is $86,600.

The ice jam migitation plans requiring modification or removal of the breakwater (Alternatives 2 and 3) are considered not favorable due to the following:

1. Lack of quantitative data or reliable qualitative evidence on which to base an opinion or belief that these options would indeed lower the ice jam flooding potential.

2. The increased potential for more severe ice jam flooding under conditions of windrow ice at the mouth of the river.

3. Loss of navigational safety for pleasure craft and commercial fishing vessels at the harbor entrance during northern storm wave periods.

4. Comparative cost.

Due to the immediate response required to successfully combat an ice jam emergency, another alternative, not detailed herein, would seem advisable for consideration wherein the City of Vermilion would upgrade their capability to execute ice breaking operations. In this way, the City can control their local problem without relying on the vessel of a federal agency that may be committed to another mission in a distant location when the urgent call for quick assistance at Vermilion is initiated.

In summary, it is highly recommended that the City of Vermilion undertake an assessment of its desire and ability to resolve ice jam problems in the Vermilion River. Upon further knowledge based on experience of the capabilities of the new 140-foot class Coast Guard icebreaker, some modification of the channel entrance may be desired. This seems to be wise only if the modifications undertaken serve to 1) reduce the probability or severity of ice jams, and 2) allow the Coast Guard ice breaking vessel greater ease of operation within the critical harbor entrance area. In this respect, the harbor entrance deepening shown in Figure 6.1 (Alternative I, Route II) contains the best balance of engineering feasibility, cost, and environmental acceptability. It will not eliminate the possibility of ice jam flooding at Vermilion, but coupled with coordinated local effort, it should reduce the probability of flooding caused by ice blockage at the river mouth and effect this reduction at a reasonable cost. Given the dangerous combination of an early thaw period and thick river ice, flooding along the Vermilion River is expected to occur in the future as it did on various occasions prior to the breakwater construction of 1973.

Design Condition No. 2: 110-Foot Coast Guard Vessel

If the Coast Guard retains the use of the 110-foot ice breaking vessel that has operated successfully at Vermilion in the past, no harbor modification or channel deepening would be required to utilize the vessel's effective ice breaking services. The ability to navigate the 110-foot vessel safely within the harbor (albeit with prudence and care) has been displayed on numerous occasions both before and after the construction of the offshore breakwater. Assuming that the authorized 12-foot depths are maintained within the harbor, ice breaking operations at Vermilion can be conducted by the 110-foot vessel if performed in a timely, prudent manner.

## 7.0 BIBLIOGRAPHY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## 8.0 APPENDIX

## 8.1 ICE TERMINOLOGY

| | |
|---|---|
| Ice Sheet: | A solid, floating, smooth unbroken ice surface. |
| Shore Ice: | A long ice sheet that is attached to the shore. |
| Ice Floe: | A free-floating piece of ice that can be a few feet to hundreds of feet across. |
| Ice Cover: | A continuous expanse of ice of any possible form, from shore to shore, in a river or a lake. |
| Ice Jam: | An accumulation of ice floes in a section of river forming a local obstruction and raising the water level upstream. |
| Fast Ice: | Ice firmly attached to shoreline or bottom. |
| Windrow: | An accumulation of drifting masses of floes pushed against the shore or fast ice by the wind; usually parallel to shore. |
| Drift Ice: | Any unattached formation of ice. |
| Pack Ice: | Accumulation of drift ice into masses upon the surface of a lake or ocean. |

## 8.2 RELEVANT CORRESPONDANCE

1. Disposition Form, Potential of Ice-Caused Flooding at Vermilion, C.R.R.E.L., August 2, 1979

2. Position Statement, Ice-Breaking Responsibility, U.S. Coast Guard to COE, Buffalo District, October 27, 1970

3. Discussion of Channel Alignment Change, Vermilion Port Authority to Mayor, November 29, 1973

4. Notification of Channel Alignment Change, COE, Buffalo District to U.S. Coast Guard, January 7, 1974

5. Statement Concerning Channel Alignment Change, U.S. Coast Guard to COE, Buffalo District, February 20, 1974

6. Request to Change Channel Alignment, COE, Buffalo District to COE, Northcentral Division, March 13, 1974

7. Approval of Channel Alignment Change, COE, Northcentral Division to COE, Buffalo District, April 2, 1974

8. Report of Ice Breaking Assistance and Emergency Operations at the Cleveland Projects Office, Winter, 1979-1980

9. Correspondance Documenting Tetra Tech - U.S. Coast Guard Communication Regarding Ice Breaking Operations

10. Cost Computations, Breakwater Modification

11. Dredge Costs, Channel Modification

12. Future Maintenance Dredge Volume Estimates

# DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| CRREL-EI | Assessment of Potential Ice-Caused Flooding along the Vermilion River, Ohio, due to the Detached Breakwater |

| TO | FROM | DATE | CMT 1 |
|---|---|---|---|
| Memo for Record | Chief, IERB | 2 August 1979<br>DEN HARTOG/lh/337 | |

1. Introduction. On 26 July Mr. Don Liddell, Chief, Engineering Division, Buffalo District, visited CRREL, IERB. He indicated that the detached breakwater at Vermilion, Ohio, might be creating ice related flooding due to ice jams and that the District Engineer wished a definitive answer. Following is the collective opinion of members of the Ice Engineering Research Branch of CRREL based upon their some 50 years of collective experience with problems of this sort.

2. Site Description. This is the site of a very old Corps project started in 1836. Two retaining walls with a 100-ft wide channel between extend some 300 and 600 feet out into the lake. These have been in place for some time and as a result long shore currents have made a beach on the east side and eroded a bay on the west. The detached breakwater, constructed in 1973, is parallel to the shore some 300 feet beyond the offshore end of the original piers. The river flows into the lake with water discharge traveling to an 8-ft channel to the west and a 12-ft deep channel to the east. Upstream the river meanders through a classic floodplain over seven miles gaining about 50 ft in elevation. The downstream 2½ miles is under the influence of lake level and the floodplain is heavily built-up and prone to summer flood damage as well as ice jam caused floods.

3. Discussion. One question that has bothered some people since construction of the detached breakwater is its possible affect on ice jams and related flooding. There have been other questions raised about the breakwater affects which are not within our area of expertise and will not be addressed.

One of the major ice features common to all the Great Lakes and easily observed is the shoreline windrow. Wind driven ice piles up along the shoreline. These ridges occur because the ice grounds to the bed, continues to ride over the ridge, breaks into smaller ice pieces resulting in a potentially high pile of ice. By mid-winter most Great Lakes shorelines have made a pile generally over six feet above lake level and often much more. Since this ice is grounded but not frozen solid to the bed, water flow through the barrier is by seepage through the mass spread out over a long distance. Those streams and rivers which discharge warm water may melt a portion of this barrier.

Windrowed ice in the lake can be a detriment to the discharge of water and ice from an inland river. Generally, the closer to shore the windrow forms, the greater the potential for ice and water blockages.

In the classic case of windrows on the lakes, people have worked with icebreakers and explosives to remove the windrow before break-up. A more permanent solution, albeit an expensive one, is a structure to force the windrow to form in deeper water and which will allow the floodwaters to pass possibly beneath the windrow to the lake but more importantly spread the river's discharge over a greater length of the windrow. This is exactly what has been done at Vermilion and no windrow related spring flooding has occurred since the construction of the detached breakwater.

The maintaining of the deep channel in the first 3/4 mi. of river is also important in reducing ice jam flooding. The deepened channel serves as a storage medium for upstream ice floes and minimizes the cross sectional area taken by the ice. In other words, the water conveyance beneath the ice jam is improved because of increased storage of ice in the deepened channel.

In short, a detached breakwater similar to that at Vermilion, Ohio, is and has been our preferred recommendation at those sites on the lakes plagued by windrow related spring flooding. Unfortunately, few municipalities have been able to afford this solution and the benefit/cost ratio has precluded Federal help. So places like Harvey, Michigan, near Marquette, plan on explosive destruction of the windrow each time flooding becomes excessive.

It must not be inferred from the previous paragraphs that Vermilion will be forever free of ice jams. In fact, the river has a history of ice jams which have occurred at the expected, classic locations; near the poorly aligned Penn Central Bridge piers, at sharp bends, channel constrictions, and due just to a change in the river's slope. These were undoubtedly caused collectively by the obstructions and the river geometry. To lessen the frequency and severity of jams within the river is another problem which might be attacked with a floating log boom across the channel and floodplain upstream of any present development. The intent of such a structure would be to hold back the river ice and form a jam at a desirable location, with minimal damage.

4. Conclusion. We believe that the detached breakwater is an asset to Vermilion for reducing ice jam flooding at the entrance to the lake. It certainly reduces water levels due to ice related floods by creating the windrow further into lake and allowing a longer diffusion front of the water from the river into the lake. But ice jams and related flooding, though unrelated to the detached breakwater, may occur again on the river upstream of the mouth and the city should not feel that the breakwater has solved the upstream ice jam problem, but it has reduced the downstream ice jam threat. We will be happy to attend and speak at a public meeting to answer any additional questions, or meet with the city officials to discuss the effect of the breakwater on future ice jams.

GUENTHER E. FRANKENSTEIN
Chief, Ice Engineering
Research Branch

2.

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER(osr)
Ninth Coast Guard District
1240 East 9th St.
Cleveland, Ohio 44199

3253
Ser, 597-70
27 October 1970

From: Commander, Ninth Coast Guard District
To: District Engineer, Buffalo District, Corps of Engineers, 1776 Niagara Street, Buffalo, New York 14207

Subj: Improvement of Vermilion Harbor

Ref: (a) COFE, Buffalo District ltr of 8 Oct 1970

1. The turning basin, as delineated in reference (a) with enclosures, will favorably effect any decision to utilize a Coast Guard vessel to relieve a flooding situation at Vermilion Harbor. However, as pointed out in recent discussions between your office, Vermilion Port Authority officials and Ninth Coast Guard District representatives, any decision to break ice in Vermilion must be predicated on several considerations, not only by Commander, Ninth Coast Guard District, but by the Commanding Officer of any vessel so assigned. These factors are discussed here in order that your office may examine all considerations when determining if allocation of additional funds required for construction of a turning basin is justified.

2. First, there must be a clearly defined threat of flooding as confirmed by your office. Second, a Coast Guard vessel must be available. Pressing requirements elsewhere and the necessity to achieve required maintenance objectives may well dictate otherwise. Third, the replacement program for our 110 foot harbor class tugs has not yet been developed and may not provide for a vessel with characteristics which permit icebreaking in Vermilion Harbor. Fourth, the final decision, which rests with the Commanding Officer of the vessel, must be predicated on the actual depth of water available at the time of need, weather conditions and the level of training which the members of his crew has achieved.

3. Coast Guard vessels assigned to icebreaking duties must maintain a strict "safety of vessel" attitude at all times and I feel constrained to point out here that operations in Vermilion Harbor are inherently hazardous and not necessarily within the capability of our vessels. Even so, commensurate of course with the considerationsnoted above, the Coast Guard is willing to make every reasonable effort to free the harbor of ice as each situation dictates.

J. NATWIG
Acting

FILE COPY

HONE · 967-5517 PHONE · 967-6989

3.

# City of Vermilion

P. O. BOX 317

VERMILION, OHIO · 44089

MEMORANDUM

November 29, 1973

To: Mayor Earl Jones
Mayor-Elect Jack Armstrong
U.S. Army Corps of Engineers ✓
Congressman Charles A. Mosher

From: John T. Trinter, Chairman
Vermilion Port Authority

Subject: U.S. Coast Guard Ice-Breaking Assistance

1. I talked with Mr. Joseph Erhart of the U.S. Army, Corps of Engineers, about changes in the easterly harbor entrance channel on Wednesday, November 21 and Monday, November 26. He advised me that a survey crew would be working in Vermilion starting November 27 to sound the entire east side of the harbor from behind the breakwall to deep water in the lake. It is estimated that the soundings would take a week to complete. The Corps would then make a detailed drawing of the harbor entrance showing all the latest soundings. This chart would then be used as the basis for determining alternate entrance channels. A copy of the chart will also be sent to the Coast Guard for use by the KAW for entering the Vermilion Harbor on the dry run and ice-breaking missions if necessary. This chart should be completed and in our hands by early December.

2. On Tuesday, November 29, 1973, I talked with Capt. Dearce, Chief of Operations, U.S. Coast Guard. The purpose of the discussion was twofold. First, I requested that the Coast Guard send the KAW to Vermilion to make a dry run into the harbor sometime this fall before the river freezes over. This measure to be taken to assure everyone that if ice jamming should occur this winter, that the KAW would, for certain, be able to navigate around the new detached breakwall and enter the Vermilion River. Capt. Dearce advised me that he would direct the KAW to make a dry run into the Vermilion River the next time she was in the area and that there would be absolutely no problem in navigating the KAW around the new breakwall and into the harbor, especially in light of the current existing high water table. Due to the energy crisis, they could not make a special trip to Vermilion to make a dry run but that the next time the KAW is operating west of Vermilion, she will come in on her way back to Cleveland.

3. I next spoke to Capt. Dearce about making a change in the direction of the easterly or deep water entrance channel. Due to shale in parts of the channel as presently designed, would it be possible to reorient the channel so

at it would go directly north to deep water in the lake. The proposed channel uld be 300 feet wide and would lie in a north - south direction. Capt. Dearce assured me that there would be absolutely no problem in bringing the KAW into the Vermilion Harbor with such a channel.

4. In further talks with the Corps of Engineers I have discovered there may be a modest cost over-run on the Vermilion Harbor Project due to an increased volume of river dredging over what was anticipated.

4.

Tech. Br.

NCBED-T

7 January 1974

SUBJECT: Vermilion Harbor, Ohio - Northeasterly Lake Approach
Channel Modification

Commander
Ninth Coast Guard District
ATTN: Captain Pearce, Chief, Operations Branch
1240 East Ninth Street
Cleveland, OH 44199

1. The Vermilion Harbor navigation project is near completion except for dredging of the northeasterly lake approach channel. We have encountered a serious problem relative to this channel due to the unanticipated existence of a massive rock shoal within the contract channel limits. We have studied several possible alternatives to the removal of this shoal. We are inclosing a preliminary drawing (Dwg. No. 64-VER-2/10A), detailing a proposed alternate channel that would provide a logical and economical solution to the problem. We request your opinions and/or recommendations relative to our proposed lake approach channel modification and its effect on your future icebreaking operations at Vermilion Harbor.

2. The westerly limit of the rock shoal mentioned above is located approximately 375 feet easterly of the east end of the new detached breakwater. Its extent is shown in red on the inclosed drawing. All sub-surface information available for the Vermilion contract indicated that it would be reasonable to assume rock at a minimum depth of 15 feet below low water datum in the area east of the new breakwater. The rock shoal was discovered when our contractor attempted to perform the anticipated earth dredging required to provide the 12-foot project depth.

3. During September 1973 we obtained soundings and probings within the contract limits of the subject channel. Based on this information we requested and received our contractor's proposal in the amount of $268,629, for removal of the rock shoal. Due to the high cost of rock removal we have studied alternate channel layouts intended to reduce or, preferable, eliminate any additional rock removal. During December 1973 we obtained additional soundings and probings over an extensive fan-shaped area east of the new breakwater. Pertinent portions of our 1973 survey data are shown on the inclosed drawing. Based on this information we have shown

jr/8208

NCBED-T
SUBJECT: Vermilion Harbor, Ohio - Northeasterly Lake Approach Channel Modification

an alternate channel layout that would provide for a 300-foot wide lake approach channel extending in a northerly direction as shown in green on the inclosed drawing. The northerly leg of the approach channel was increased to the 300-foot width in order to provide greater maneuvering room for your vessel during icebreaking operations. This alternate channel would not require any additional earth or rock dredging and would probably result in a no-cost modification. All other alternatives would require costly contract modifications. Since local interests are required to contribute 42% of the total project cost, any monetary modification would involve a corresponding increase in their final contribution.

4. It is noted that your tug is the only vessel, entering Vermilion Harbor, that requires a 12-foot project depth. All other commercial vessels and pleasure craft currently using the harbor require less than 8-foot depth and would not have to be restricted to the proposed 300-foot wide approach channel.

5. Since the welfare and safety of the City of Vermilion may be dependent upon future icebreaking assistance from the Coast Guard, no alternative solution is feasible unless it provides the capability for your continued icebreaking operations. We would appreciate a statement from you as to whether the proposed channel is acceptable as a substitute for the one previously planned. If you desire further information relative to the proposed contract modification, we will be pleased to furnish it upon request.

6. We are inclosing a copy of your letter dated 27 October 1970, SER 597-70 for your ready reference. This correspondence relates to your initial decisions concerning our Vermilion Harbor project.

7. If you determine that the alternative channel is acceptable for Coast Guard operational purposes, we will then contact our higher authority to obtain permission to depart from the currently approved approach channel alignment. If permission is granted, project maps will be altered and interested agencies will receive appropriate notification of the change.

Incl
as

CHARLES T. MYERS III
Major, Corps of Engineers
Acting District Engineer

COPY FURNISHED:
John Trinter, Chairman
Vermilion Port Authority

Robert Lucas
Ohio Dept. of Nat. Res.

Congressman Charles A. Mosher

NCBED-T

Tab PR. 5.

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER (OST)
Ninth Coast Guard District
1240 East 9th St.
Cleveland, Ohio 44199
Phone: 216-522-3981

3253
Ser, 25-74
20 February 1974

Charles T. Myers III
Major, Corps of Engineers
Acting District Engineer
1776 Niagara Street
Buffalo, New York 14207

Dear Major Myers:

Your letter of 7 January 1974 regarding proposed Northeasterly lake approach channel modification for Vermilion Harbor has been carefully studied.

The modification in regard to icebreaking operations should pose no problem since the area would be ice covered and sea conditions which could otherwise prove a problem would be minimal. The capability for continued icebreaking operations should not be impaired and the proposal is acceptable.

Sincerely,

A C Pearce

A. C. PEARCE
Captain, U. S. Coast Guard
Chief, Operations Division
By direction of Commander,
Ninth Coast Guard District

Tech Br.

6.

NCBED-T 13 March 1974

SUBJECT: Vermilion Harbor, Ohio

Division Engineer, North Central
ATTN: NCDED-T

1. In accordance with ER 1110-2-1200, paragraph 13h, a revision to the approved plans and specifications for the subject project is submitted for approval.

2. The following information relating to the work covered by the revision is submitted for your ready reference:

a. The Vermilion Harbor navigation project is near completion except for dredging of the northeasterly lake approach channel. We have encountered a serious problem relative to this channel due to the unanticipated existence of a massive rock shoal within the contract channel limits. We have studied several possible alternatives to the removal of this shoal. We are inclosing a preliminary drawing (Dwg. No. 64-VHR-2/10A), detailing a proposed alternate channel that would provide a logical and economical solution to the problem.

b. The westerly limit of the rock shoal mentioned above is located approximately 375 feet easterly of the east end of the new detached breakwater. Its extent is shown in red on the inclosed drawing. All subsurface information available for the Vermilion contract indicated that it would be reasonable to assume rock at a minimum depth of 15 feet below low water datum in the area east of the new breakwater. The rock shoal was discovered when our contractor attempted to perform the anticipated earth dredging required to provide the 12-foot project depth.

c. During September 1973 we obtained soundings and probings within the contract limits of the subject channel. Based on this information we requested and received our contractor's proposal in the amount of $268,629, for removal of the rock shoal. Due to the high cost of rock removal we have studied alternate channel layouts

NCBED-T
SUBJECT: Vermilion Harbor, Ohio

intended to reduce or, preferably, eliminate any additional rock removal. During December 1973 we obtained additional soundings and probings over an extensive fan-shaped area east of the new breakwater. Pertinent portions of our 1973 survey data are shown on the inclosed drawing. Based on this information, we have selected an alternate channel layout that would provide for a 300-foot wide lake approach channel extending in a northerly direction as shown in green on the inclosed drawing. The northerly leg of the approach channel was increased to the 300-foot width in order to provide greater manouvering room for Coast Guard vessels during icebreaking operations. This alternate channel would not require any additional earth or rock dredging and would probably result in a no-cost modification. All other alternatives would require costly contract modifications. Since local interests are required to contribute 42% of the total project cost, any monetary modification would involve a corresponding increase in their final contribution.

d. It should be noted that the Coast Guard tug is the only vessel, entering Vermilion Harbor, that requires a 12-foot project depth. All other commercial vessels and pleasure craft currently using the harbor require less than 8-foot depth and would not have to be restricted to the proposed 300-foot wide approach channel.

e. Since the welfare and safety of the City of Vermilion may be dependent upon future icebreaking assistance from the Coast Guard, no alternative solution is feasible unless it provides the capability for their continued icebreaking operations. We contacted the Ninth Coast Guard District at Cleveland and requested their concurrence with our channel realignment proposal. A copy of their affirmative reply, dated 20 February 1974, is inclosed.

3. Request approval of the above-mentioned revision to the approved plans and specifications for subject project.

4. Upon receipt of your approval, the necessary contract modification will be consummated. Contract completion scheduled for 31 May 1974 will not be affected since no additional work is required.

2 Incl
1. Coast Guard ltr
2. Dwg No. 64-VER-2/10A
(both in quad)

BERNARD C. HUGHES
Colonel, Corps of Engineers
District Engineer

CF:
NCBED-T
NCBCO

NCDED-T (13 Mar 74) 1st Ind
SUBJECT: Vermilion Harbor, Ohio

DA, North Central Division, Corps of Engineers, 536 South Clark Street, Chicago, Illinois 60605 2 April 1974

TO: District Engineer, Buffalo

1. The proposal to provide an alternate channel for subject project is approved.

2. Final contract plans and specifications for subject project were not received by this office. It is requested that a set of contract plans and specifications be forwarded to NCDCO-C, NCDED-F, and NCDED-T.

FOR THE DIVISION ENGINEER:

Incl
wd

L. H. BLAKEY
Chief, Engineering Division

# DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| NCBCO-CL | Report of Ice Breaking Assistance and Emergency Operations at the Cleveland Projects Office Winter of 1979-80. |

TO Emergency Operations Officer FROM Cleve Projs Eng DATE 2 April 1980 CMT 1
Matricardi/hha FTS 293-4957

In the following narrative report is a summary of all emergency operations which were supervised by the Cleveland Projects Office during the winter of 1979-80. Ice breaking assistance was limited to the Rocky River, Vermilion River, and Grand River. The report also gives the weather and ice conditions on various days. The Coast Guard will also be sending reports from the Captains of the ice breakers to H. Vitale. The lake level during this period was -3.0.

Friday, 25 JAN 80

Ice began to form inside the breakwall in the harbor at Cleveland.

Monday, 28 JAN 80

Lake is completely frozen over as of today.

Monday, 11 FEB 80

South winds moved the ice away from the shoreline. Ice breakers Arundel and Raritan are now in Cleveland.

Thursday, 14 FEB 80

Rocky River - River frozen smooth from entrance light upstream. Lake is clear from entrance light north.

Saturday, 16 FEB 80

North winds have blown the ice back in to the shoreline.

Monday, 18 FEB 80

South winds have started moving the ice away from the shoreline again.

Rocky River - River frozen smooth from entrance light upstream. From entrance light north for 600 feet is windrowed ice, then open lake.

Weather - Predicting high temperatures of 40°-45°F on Wednesday, with possible rain.

Tuesday, 19 FEB 80

Called Coast Guard, Detroit, and alerted them of possible ice jams this week.

NCBCO-CL Subject: Report of Ice Breaking Assistance and Emergency Operations at the Cleveland Projects Office, Winter of 1979-80.

Vermilion River - Smooth ice from breakwall upstream. Windrowed ice from breakwall for 300 feet north, then open lake. Mayor Johnson requested Coast Guard assistance. Vermilion ice breaker broke river ice from the Water Treatment Plant downstream to the east side of the breakwater.

Grand River - Smooth ice from entrance light upstream. Open lake north of the entrance light.

Called Coast Guard, Detroit, at 1545 and requested an ice breaker be sent to Vermilion, Rocky River, and Fairport to do some preventive ice breaking.

Rocky River - Smooth ice from entrance light upstream. Open area at Detroit Avenue Bridge. Windrowed ice from entrance light north for 300 feet, then open lake.

Wednesday, 20 FEB 80

Vermilion River - Coast Guard cutter ARUNDEL arrived at 1100 hours and broke ice on the north, east, and west sides of the breakwall. It then broke ice inside the harbor and from the breakwall upstream to Sta. 50+00. The ARUNDEL was drafting 11.5 feet. Ice breaking was completed at 1500 hours.

Rocky River - Coast Guard cutter ARUNDEL arrived at 1710 hours and broke ice to within 200 feet north of the entrance light, and could not go further due to shallow depths encountered at the entrance channel.

Weather - Rain today with a high temperature of 42°F.

Thursday, 21 FEB 80

Grand River - Coast Guard cutter ARUNDEL arrived at 1230 and broke a channel up the river from the entrance light to the end of navigation.

Weather - High today 37°F. Forecast for tomorrow is 90% chance of rain and winds from the southeast.

Friday, 22 FEB 80

Rocky River - River ice began to break up at 1500 hours. An ice jam formed in the East Channel from approximate Sta. 35+00 to 43+00, but it was not jammed to the bottom of the river. The West Channel was clear of ice and the water level was not rising. No other ice upstream.

Vermilion River - Ice at Mill Hollow Park began to break up at 1600 hours and formed an ice jam at the Route 2 bridge. From Rt 2 to Penn Central bridge was sheet ice and from Penn Central

Bridge to the mouth of the river was clear. Vermilion ice breaker was broken down.

Grand River - Ice moving out of the river with no ice jams.

Saturday, 23 FEB 80

Rocky River - River is almost completely clear of ice, except for windrows at the mouth. No ice left in the river.

Vermilion River - Ice jam at Route 2 bridge has moved downstream to the Olympic Park area and is approximately 1 mile long and causing flooding around approximately 20 homes in the Olympic Park area. There is approximately 500 yards of sheet ice downstream of the ice jam and then the river is open all the way to the lake. The Vermilion ice breaker is being repaired.

Sunday, 24 FEB 80

Vermilion River - Situation same as yesterday, water level down slightly but houses still being flooded at Olympic Park.

Weather - High temperature 30°F. Winds from the west and forecast to be from northeast tonight with snow flurries.

Monday, 25 FEB 80

Vermilion River - City of Vermilion attempted to remove the ice jam with a front end loader. Removed approximately a 100/yd channel which helped increase the flow under the ice jam. People returned to their homes in Olympic Park.

Tuesday, 26 FEB 80

Vermilion River - Ice jam settled on the river bottom now, no water backing up behind it. Skim ice forming in the river.

Wednesday, 27 FEB 80

Weather - Very cold, high of 25°F and overnight low of 15°F.

Thursday, 28 FEB 80

Weather - High of 22°F and overnight low of 10°F. The lake is frozen at the shoreline again. All rivers are re-freezing again.

NCBCO-CL Subject: Report of Ice Breaking Assistance and Emergency Operations at the Cleveland Projects Office, Winter of 1979-80

Grand River - Coast Guard Cutter ARUNDEL went from the mouth of the Grand River to the end of navigation and broke a channel.

Friday, 29 FEB 80

Weather - High of 15°F and overnight low of 0°F.

Saturday, 1 MAR 80

Weather - High of 15°F and overnight low of 5°F.

Sunday, 2 MAR 80

Vermilion River - Vermilion ice breaker is running again and has broken the river ice from the Water Treatment Plant to the breakwall.

Weather - High of 20°F and overnight low of 6°F.

Monday, 3 MAR 80

Rocky River - Southwest winds have moved the ice away from shore again. Lake clear approximately 200 yards north of the entrance light. River is ice covered, but ice is thin.

Weather - High of 25°F. Forecast tomorrow of 40°F, southwest winds and 20% chance of rain.

Tuesday, 4 MAR 80

Vermilion River - River ice covered from the ice jam to 100 yards north of the breakwall.

Weather - Forecast for rain tonight and tomorrow.

Wednesday, 5 MAR 80

Rocky River - River clear from Detroit Avenue upstream, and sheet ice down to the mouth. No possibility of further ice jams here.

Grand River - Requested an ice breaker to alleviate possible flooding. An ice jam formed at the B&O railroad bridge last night, but is not causing flooding yet. Coast Guard Cutter RARITAN arrived at 1500 hours and broke a channel from the mouth to the end of navigation.

NCBCO-CL Subject: Report of Ice Breaking Assistance and Emergency Operations at the Cleveland Projects Office, Winter of 1979-80.

Weather - Rain today, high of 40°F and winds from the southwest and to change to northwest tonight.

Thursday, 6 MAR 80

Weather - High of 33°F and overnight low of 15°F. Winds from the southwest.

Friday, 7 MAR 80

Grand River - Ice has blown in to the mouth of the river. Ice jam still at the B&O railroad bridge.

Weather - Heavy rains tonight from 1500 to 2300 hours.

Saturday, 8 MAR 80

Vermilion River - Water level rose to flood level behind the ice jam and flooded the Olympic Park and Riverside Drive areas. River clear downstream of ice jam except for thin sheet of ice and some windrowed ice at the mouth of the river. Vermilion ice breaker broke up the remaining sheet ice downstream of the ice jam and broke loose approximately 100 yards of the ice jam. Freed ice flowed to the mouth of the river and stayed in the river. Water receded at Olympic Park and Riverside Drive.

Sunday, 9 MAR 80

Vermilion River - Ice at the mouth of the river had frozen together overnight. Mayor Johnson requested an ice breaker to clear the ice at the mouth of the river while the Vermilion ice breaker tried to free the remaining ice jam. Olympic Park and Riverside Drive are flooded again. Coast Guard stated they could not send an ice breaker until Monday. Vic Monz, a contractor from Lorain, Ohio, sent a tug to help move the ice at the mouth. At 1300 hours the Vermilion ice breaker hit the ice jam and caused the entire jam to start moving downstream. The ice jam moved downstream with a strong current with no further ice jams, and emptied into the lake. All ice was gone from the river by 1500 hours.

Monday, 10 MAR 80

Grand River - Ice still jammed at the B&O railroad bridge, and the water level behind the jam is approximately 4 feet higher than downstream. Ice downstream of the jam was floating freely. Water level receded later, and all ice moved out of the river during the next couple of days.

NCBRO-CL Subject: Report of Ice Breaking Assistance and Emergency Operations Cleveland Projects Office, Winter of 1979-80

EVALUATION OF COAST GUARD ICE BREAKING

Vermilion River - Ice breaking on 20 Feb 80 was extremely effective in allowing the mouth and upstream to the Rt 6 bridge to be clear. If the Vermilion ice breaker had not broken down on 22 Feb the entire river could have been cleared and there may not have been any ice jams at all. The Coast Guard ice breaking also generated positive comments of Corps and Coast Guard assistance from Vermilion residents and local news media.

Rocky River - Ice breaking on 20 Feb was completely ineffective due to the Coast Guard cutter only being able to get within 200 feet of the entrance light due to shallow depths in the entrance channel. Dredging of the river this spring should alleviate that problem.

Grand River - Ice breaking on 21 Feb. and 5 Mar. did not alleviate or prevent any ice jams. The ice breaking did generate positive comments of Corps and Coast Guard assistance from Fairport Harbor residents and local news media. In other words, "We did all that we could."

SUMMARY

In my opinion, the preventative ice breaking done this season did help at the Vermilion River. Of course, it is very difficult to predict exactly whether an ice jam will occur or not, and where. I feel the preventative ice breaking makes the local residents feel that the Corps and the Coast Guard are doing all they can to prevent any ice jam flooding. Also if the weather, wind, and rain conditions are right, the preventative ice breaking will be beneficial. Therefore, I recommend the same procedure be followed next year.

John S. Matricardi

JOHN S. MATRICARDI
Cleveland Projects Engineer

CF: LEE HAIR

COAST GUARD ICE BREAKING OPERATIONS, VERMILION, OHIO

Meeting of October 11, 1979:

Jim Henry, Joan Pope: Buffalo District
George Watts: Tetra Tech
Captain Millradt, Commander Martin: U.S. Coast Guard

The Coast Guard representatives indicated that their new vessel for ice breaking operations in Lake Erie will require 15 feet of water for ice-breaking operations; therefore, that channel depth must be available at Vermilion Harbor for them to respond to calls for assistance. They pointed out that operation within the present easterly channel entrance, and with the ninety degree turn into the jetty channel, was very hazardous and probably an unacceptable condition for their new class vessel. Entrance via the east channel and proceeding westerly between the detached breakwater and the jetties to exit out of the west channel would be an acceptable ice breaking route and condition providing there was the 15-foot of water depth in the easterly and westerly channels. They felt that a breach in the detached breakwater with adequate channel depth would improve their ice breaking operations, however they pointed out the necessity of having an area (15-foot water depth) between the breakwater and jetty ends wherein the vessel could be turned around for exit purposes.

COAST GUARD ICE BREAKING OPERATIONS, VERMILION, OHIO

Telephone Conversation, November 20, 1979:

Peter Gadd, Tetra Tech
Mr. Graham, Engineering Officer, CG Vessel Bristol Bay

The Bristol Bay is a new 140-foot Coast Guard ice breaker (12.5' draft, 37.5' beam). Presently, the vessel is based in Detroit but may be moved to Cleveland.

Vessel can move astern along ice broken route, however, being a single-screw vessel, she will back to port if the ice is not strong enough to guide the vessel. A turning basin having a diameter of 600 feet would be required to allow safe turning if backing must be avoided. While backing may not be acceptable under all weather and ice conditions, it appears that this requirement would not prevent well-planned and timely ice breaking operations by the new 140-footer.

COAST GUARD ICE BREAKING OPERATIONS, VERMILION, OHIO

Telephone Conversation, June 25, 1980

Peter Gadd, Tetra Tech
Captain Charles Millradt, U.S. Coast Guard

The Coast Guard vessel Arundel (110-footer) performed ice breaking operations at Vermilion during the past winter. The Arundel will soon become the last 110-footer operated by the Coast Guard on Lake Erie and will remain in Cleveland for one or two more seasons. Implementation of the new, 140-foot ice breakers has begun.

No standard, accepted ice breaking maneuvers by the Coast Guard's 110-footers exist at Vermilion. The commanding officers of each vessel must, at the time of ice breaking, determine the extent and mode of operation. This is highly dependent upon the existing conditions of ice jam extent, river flow, and wind/weather conditions. These vessels have not always proceeded upriver between the entrance piers when hazardous conditions exist.

The exact abilities and limitations of the new 140-footers are highly speculative at this time. The precise level of maneuverability of these large, single-screw vessels is not yet fully documented and the ease with which they may break ice at the Vermilion Harbor is not yet clear. It is highly doubtful that these vessels could ever safely navigate upriver past the ends of the Harbor piers.

| TETRA TECH INC. PASADENA, CALIF. | SUBJECT: BREAKWATER REMOVAL COST COMPUTATIONS | PROJECT: TC 3317-02 |
|---|---|---|
| | COMPUTED: PCL CHECKED: | FILE NO: DATE: PAGE 1 OF 1 PAGES |

FROM: LUECKE ENGINEERS, FRANKFORT, MICHIGAN
ORIGINAL CONSTRUCTORS OF BREAKWATER

1). COST OF REMOVAL = $70,000 (FOR 1 SHEET PILE CELL AND 2 ATTACHED STEEL MEMBRANES)

2). MOBILIZATION COST = $10,000

3). IF ENTIRE BREAKWATER IS REMOVED, TOTAL COST WOULD BE DECREASED 15% FROM #1) and #2), above

FOR BREAKWATER GAP (200' IN WIDTH):

5 CELLS + 6 MEMBRANE PAIRS REQUIRE REMOVAL:

| ITEM | COST |
|---|---|
| MOBILIZATION: | $10,000 |
| REMOVE 5 CELLS + 5 MEMBRANE PAIRS: (5 × $70,000) | 350,000 |
| REMOVE 1 MEMBRANE PAIR: (1/4 × $70,000) | 17,500 |
| TOTAL | $377,500 |

FOR ENTIRE BREAKWATER

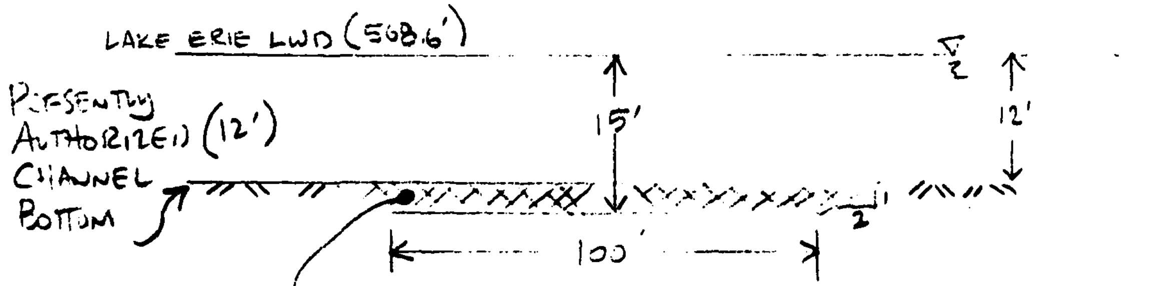
22 CELLS + 21 MEMBRANE PAIRS

| ITEM | COST |
|---|---|
| MOBILIZATION | $10,000 |
| REMOVE 21 CELLS + 21 MEMBRANES: (21 × $70,000) | 1,470,000 |
| REMOVE 1 CELL (3/4 × $70,000): | 52,500 |
| TOTAL | $1,532,500 |
| 15% DISCOUNT: | − 229,875 |
| TOTAL: | $1,302,625 |

| TETRA TECH INC. PASADENA, CALIF. | SUBJECT DREDGE COSTS VERMILION OHIO<br>COMPUTED RLY CHECKED | PROJECT TC 3319-02<br>FILE NO<br>DATE 6-4-80 PAGE 1 OF 4 PAGES |
|---|---|---|

1) ASSUME 12 FOOT AUTHORIZED DEPTH IS MAINTAINED EVERYWHERE WITHIN THE CONFINES OF THE APPROACH CHANNEL AND THE HARBOR

2) ASSUME THE CREATION OF A 15-FOOT DEEP CHANNEL WITH CROSS-SECTIONAL DIMENSIONS AS FOLLOWS:




CHANNEL REQUIRED FOR 140-FOOT VAST ... VESSEL

COMPUTE: ADDITION DREDGE REQUIREMENT FOR 100-FOOT WIDE CHANNEL WITH 1/2 SIDE SLOPES

$$\text{Volume (C.Y.)}/\text{LF} = \frac{3}{2}(100 + 112) = 318 \frac{SF}{LF} = 12 \frac{CY}{LF}$$

THUS, WITHIN THE HARBOR:
FOR EACH LINEAL FOOT OF THE NEW 15 FOOT DEEP CHANNEL, 12 CUBIC YARDS MUST BE DREDGED.

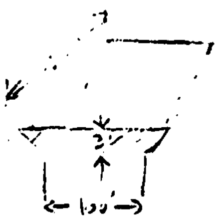
SIMILARLY, WITHIN THE 13-FOOT HARBOR CHANNEL WEST OF BREAKWATER, CREATION OF A 15-FOOT CHANNEL REQUIRES A DREDGE QUANTITY OF 30 C.Y./LF; HOWEVER, THIS MUST BE DIVIDED BETWEEN ROCK AND SEDIMENT REMOVAL.

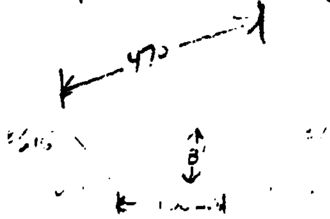
| TETRA TECH INC. PASADENA, CALIF. | SUBJECT DREDGE COSTS<br>VERMILION, OHIO<br>COMPUTED RLY CHECKED | PROJECT<br>FILE NO<br>DATE 6.4.80 PAGE 2 OF 4 PAGES |
|---|---|---|

## ALTERNATIVE I, ROUTE I

LENGTH OF CHANNEL, FEET

| ① 15 Foot Contour To 12 Foot Channel | ② Within Harbor (12') | ③ Within Harbor (8') | ④ 8 Foot Contour (Harbor) To 15 Foot Contour |
|---|---|---|---|
| 300' | 950' | 500' | 470' |
| Approximate Slope = $\frac{1}{100}$ | $\times 12 \frac{CY}{LF}$ | $\times 30 \frac{CY}{LF}$ | Approximate Slope = $\frac{7}{470} \approx \frac{1}{70}$ |
| | 11,400 C.Y. | 15,000 C.Y. | |




FROM "AVERAGE END AREA" METHOD:
$V = 1767$ C.Y.

FROM "AVERAGE END AREA" METHOD,
$V = 8077$ CY

## ALTERNATIVE I, ROUTE I DREDGE REQUIREMENT

$V_1 = 1767$

$V_2 = 11400$

$V_3 = 15000$

$V_4 = 8077$

36,244 OF WHICH IS 400 C.Y. IS ROCK (WEST CHANNEL)

THUS, DREDGE QUANTITY = 16,600 CY OF ROCK

19,600 CY OF SEDIMENT

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT Dredge Costs
Vermilion, Ohio
COMPUTED RJ CHECKED

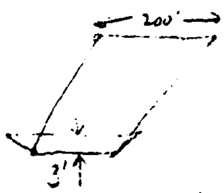
PROJECT
FILE NO
DATE 6.4.80 PAGE 3 OF 4 PAGES

ALTERNATIVE I, ROUTE II

LENGTH OF CHANNEL FROM 15-FOOT CONTOUR TO 12 FOOT CHANNEL, FT.

300'

CHANNEL WIDTH 200'



$V = 3433$ C.Y.

LENGTH OF CHANNEL WITHIN PRESENT HARBOR, FT.

525
× 12 CY/LF

6300 CY

ADDITIONAL AREA WITHIN HARBOR, SF

$\frac{1}{2} \cdot 500 \cdot 125 =$
a) 31250 SF
b) $\frac{1}{2} \cdot 225 \cdot (230-50) =$ 20250 SF
a) + b) = 51,500

$V_3 = \frac{51500 \cdot 3}{27} = 5722$ CY

DREDGE REQUIREMENT

$V_1 = 3433$

$V_2 = 6300$

$V_3 = 5722$

15,455 ≈ 15,500 CY AS OF [illegible] SEDIMENT

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT Dredge Costs
[illegible] Ohio
COMPUTED PLY. CHECKED

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ALTERNATIVE II - DREDGE COSTS

1) CHANNEL [illegible] OF [illegible]
[illegible] DEPTH [illegible]
[illegible] 15
ASSUME SIDE SLOPE = 1:2
LENGTH OF 15' CHANNEL = 440
[illegible] 150'

DREDGE VOLUME, $V_1 = \frac{3}{2}(150-162) \cdot \frac{440}{27} = 7627$ cy

2) CHANNEL FROM 15-FOOT CONTOUR TO [illegible]
ASSUMED SLOPE 1:100
DESIRED DEPTH = 3'
SIDE SLOPE = 1:2
LENGTH = 450
BOTTOM WIDTH = 150'

[illegible] Volume $= \frac{3}{2}(150+162) * \frac{1}{2} * \frac{450}{27} =$ [illegible]

[illegible] = 11,527 cy

[illegible] 2,253 CY IS ASSUMED [illegible]

[illegible] P [illegible]

[illegible] 2,253 c → 2,400 cy

[illegible] 9163 CY → 9,200 cy

| | | |
|---|---|---|
| TETRA TECH INC. PASADENA, CALIF. | SUBJECT Expected Dredge Requirements — Alternative 1 | PROJECT TC-3319-02 |
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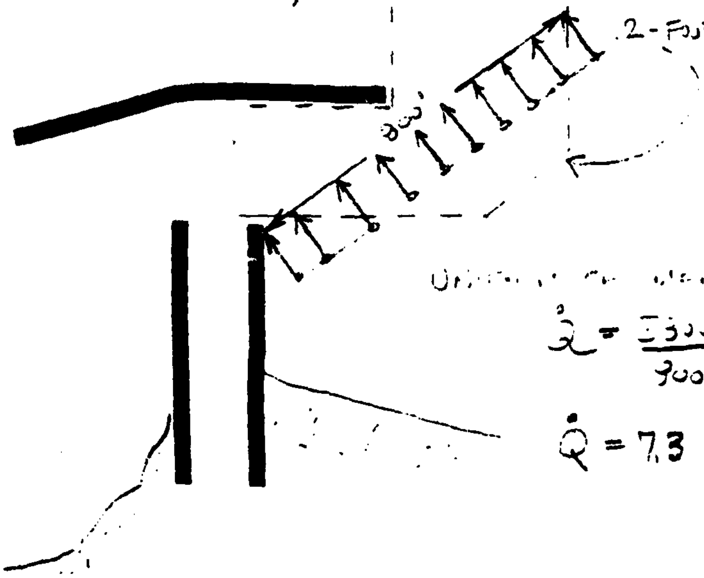
GIVEN: VERMILION HARBOR, OHIO
AVERAGE ANNUAL DREDGE QUANTITY FOR MAINTENANCE OF 12-FOOT ENTRANCE = 5300 C.Y.

FIND: AVERAGE ANNUAL DREDGE QUANTITY IF ENTRANCE CHANNEL HAVING 15-FOOT DEPTH IS CONSTRUCTED AS SHOWN IN PLAN ALTERNATIVE 1.

ASSUME: PRESENT DREDGE QUANTITY ARRIVES FROM EAST BEACHES UNIFORMLY ALONG TRANSECT BETWEEN EAST PIER END AND NORTHERN LIMIT OF EAST CHANNEL, AS SHOWN [illegible]

12-FOOT CHANNEL LIMIT




NOT DRAWN TO SCALE

UNIT [illegible] FLUX,

$$\dot{Q} = \frac{5300}{900} \text{ CY/LF-YEAR}$$

$$\dot{Q} = 7.3 \text{ C.Y./LF-YEAR}$$

NOW FOR 15-FOOT CHANNEL IN LEE OF [illegible] NO CHANGE IS EXPECTED DUE TO THE SEDIMENT IMPOUNDMENT CAPABILITY [illegible] THE THREE FEET OF [illegible] SEDIMENT THAN THAT DELIVERED TO IT AT THE ABOVE RATE, $\dot{Q}$.

| TETRA TECH INC. PASADENA, CALIF. | SUBJECT EXPECTED DREDGE REQUIREMENTS - ALTERNATIVE 1 | PROJECT TC-3373-02 |
|---|---|---|
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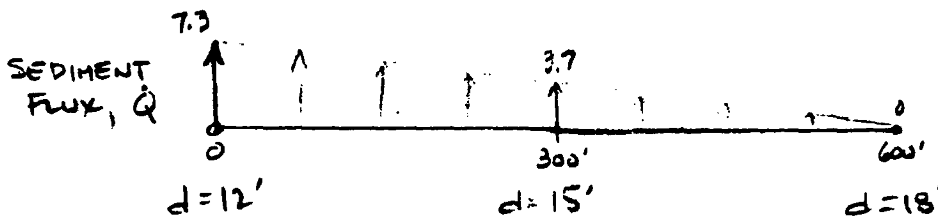
| | | DATE 3-30-80 PAGE 2 OF 4 PAGES |

FOR A 15-FOOT CHANNEL TO THE NORTH OF THE BREAKWATER:

<u>ASSUME</u>: SEDIMENT FLUX AT 12-FOOT DEPTH = 7.3 CY/LF-YR

LONGSHORE SEDIMENT FLUX AT 18-FOOT DEPTH = 0
WITH LINEAR VARIATION ALONG
600' DISTANCE BETWEEN 12 AND 18 FOOT CONTOURS.




<u>FIND</u>: TOTAL SEDIMENT FLUX BETWEEN 12-FOOT AND 15-FOOT CONTOURS.

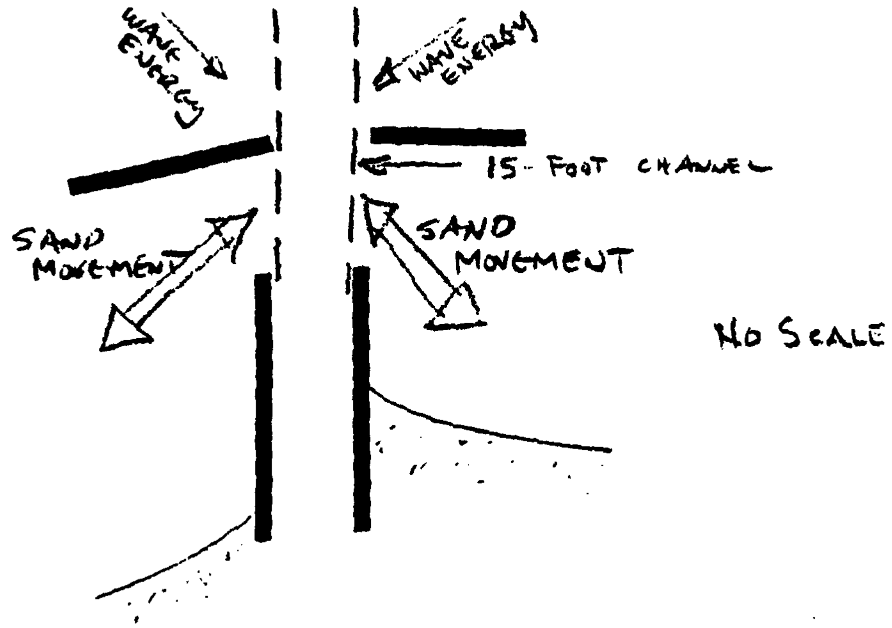
$$Q = \frac{1}{2}\,300\,(7.3 + 3.7) = 1650 \text{ C.Y./YEAR}$$

THUS, TO MAINTAIN A 15-FOOT CHANNEL AT VERMILION HARBOR,
THE EXPECTED ANNUAL DREDGE VOLUME WOULD BE:

| EXISTING | + | ADDITIONAL | = | TOTAL |
|---|---|---|---|---|
| ↓ | | ↓ | | ↓ |
| 5800 | + | 1650 | = | 7,450 CY/YEAR |

| TETRA TECH INC. PASADENA, CALIF. | SUBJECT EXPECTED DREDGE REQUIREMENT – ALTERNATIVE 2 | PROJECT TC-3319-02 |
|---|---|---|
| | COMPUTED PGG CHECKED | FILE NO. |
| | | DATE 6-30-9? PAGE 2 OF 4 PAGES |

ALTERNATIVE 2: BREAKWATER BREACH WITH 15-FOOT CHANNEL




DUE TO WAVE ENERGY INPUT THROUGH THE BREAKWATER GAP, THE SHOALING AT THE RIVER MOUTH IS EXPECTED TO DIMINISH TO ABOUT 50% OF ITS PRESENT VALUE (5800/2 = 2900 CY/YEAR).

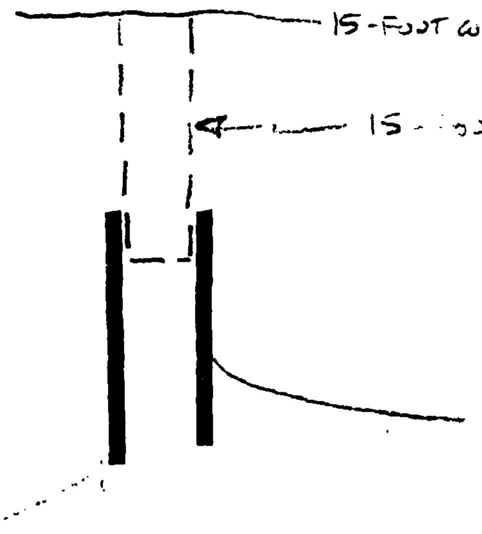
SHOALING IN THE ENTRANCE CHANNEL BETWEEN THE BREAKWATER AND THE 15-FOOT CONTOUR IS EXPECTED TO REMAIN THE SAME (= 1650 CY/YR) AS THAT DETERMINED FOR ALTERNATIVE #1.

TOTAL MAINTENANCE DREDGE VOLUME =

2900 + 1650 = 4,550 C.Y./YEAR

| TETRA TECH INC. PASADENA, CALIF. | SUBJECT: EXISTING DREDGE REQUIREMENTS – ALTERNATIVE 3 | PROJECT: TC-[illegible]-02 |
|---|---|---|
| | COMPUTED: PCC CHECKED: | FILE NO: |
| | | DATE 6-30-80 PAGE 4 OF 4 PAGES |

ALTERNATIVE #3: BREAKWATER REMOVAL WITH 15-FOOT CHANNEL




NO PRE-1973 DREDGE RECORDS HAVE BEEN EXAMINED TO DETERMINE THE EXTENT OF MAINTENANCE DREDGING PRIOR TO BREAKWATER [illegible]. HOWEVER, THE THREE FEET OF ADDED DEPTH IS EXPECTED TO SHOAL UNDER THE INFLUENCE OF THE LONGSHORE LITTORAL [illegible] THAT [illegible] THE HARBOR. THE AVERAGE VOLUME OF THIS [illegible] THE MAINTENANCE DREDGING [illegible] OF ALTERNATIVE #1, IS 7,450 CY/YEAR

END